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RAILWAY SPEED AND SAFETY

On reading the Government Inspector's report, summarised in our issue of September 16th, on the railway accident at Sutton Coldfield in January last, readers passing beyond middle age will no doubt recall three serious accidents that came in quick succession some fifty years ago, at Shrewsbury, Grantham and Salisbury, and all in 1906. All of them had some points of marked resemblance to Sutton Coldfield, in that a driver of first-class experience and high reputation ran at inexplicably high speed on a sharp curve and wrecked his train. In every case the driver and fireman were killed, and the true reasons for the apparent lapses will, in all probability, never be known. To-day, as in 1906, the thoughts of many turn to possible means of preventing such accidents, and Colonel Wilson in his recently published report devotes particular attention to the possible elaboration of the warning signs now used in some localities where speed restrictions are enforced. He refers to the more precise working that may be expected in the age of diesel and electric locomotives into which British Railways are now entering, and questions whether the old practice of relying upon a driver's knowledge of the route should not give place to a uniform procedure of " sign-posting " the line—at any rate, so far as speed restrictions are concerned. In one respect, however, Sutton Coldfield differed from the high speed derailments of 1906. All the latter occurred on the regular routes of the trains concerned, with the regular drivers in charge, whereas the recent accident took place on a diversion route available for, but rarely used by, through passenger trains. Thus, while in the former cases the enginemen's familiarity with the route and duty might conceivably have induced a moment's inattention, or even dozing, since the accidents all occurred at night, at Sutton Coldfield a local driver had joined the ill-fated train at Burton to pilot the regular crew over the diversion route.

It was while this local man, put on because of his local knowledge, was in charge, that the derailment occurred. One can be fairly certain that he was aware of the 30 m.p.h. restriction through Sutton Coldfield station, and yet he took the curve at 55–60 m.p.h. But no regular fast trains pass that way, and it is just conceivable that though sufficiently aware of the curve itself, he did not appreciate the effects of taking it at speed ; for, as Colonel Wilson concludes, it was not a case of misjudgment, but of completely ignoring the speed order. In the circumstances one is inclined to doubt if a prominent lineside notice of the restriction would have had any effect. On certain main lines in recent years speed measuring devices have been installed at locations where restrictions are permanently imposed, so that cases of excessive speed can be recorded. This, coupled with the fitting of speedometers on all express passenger and mixed traffic locomotives concerned, has, over a period of years, resulted in a far more accurate observation of speed limits than obtained twenty to twenty-five years ago. A speed discipline has become traditional. Elsewhere on British Railways one can observe wide fluctuation in the way in which speed orders are interpreted. On the former L.N.E.R., when the streamlined trains were introduced in 1935, the locomotives concerned were fitted with the Flaman type of speed recorder and a graphic record of every journey was taken ; thus, in cases of excessive speed the driver could be cautioned, or disciplined accordingly. None of these devices, however, can actually prevent a derailment due to excessive speed ; their existence merely acts as a deterrent. The only sure way to safeguard a train in the event of reckless running is to install an instantaneous

speed-measuring device to work in conjunction with the brake application feature of the automatic train control.

Even this would be unlikely to prevent an accident such as that at Sutton Coldfield, for the simple reason that equipment with such devices would for many years be confined to the main lines. While we agree that more precise working may be expected when the newer forms of motive power are brought into service the route mileage affected must necessarily be small at first and reliance will still be placed upon the good sense and inherent instincts of safe working bred into successive generations of British railwaymen. That tradition, and the sense of high responsibility that it cultivates, is an operational asset that must not on any account be allowed to languish with the introduction of an increasing number of safety devices on locomotives and in signal-boxes. In the past certain features of operation that we should now regard as fundamental beyond any doubt—the space interval between trains, for example—were originally opposed by some locomotive superintendents on the grounds that they would induce slackness among enginemen, once they were relieved of the necessity of keeping a constant lookout for the train ahead ! We would not go so far as that ; neither would we regard certain disquieting features of the Sutton Coldfield accident as symptomatic of a decline in operational discipline. But the newer forms of motive power, together with their promise of more precise working and greater personal comfort for their crews must be regarded as an incentive to all-round increases in operational efficiency, and a greater sense of alertness and responsibility than ever—appropriate to the considerably higher scheduled speeds that are promised to us. To the attainment of that end the laying out by British Railways of the vehicle and track testing installation to which we referred in our issue of September 30th, may well make a welcome contribution.

A LESSON FOR LAND-LUBBERS

It is very remarkable to observe as the years pass how almost without exception the presidents of the Institution of Mechanical Engineers in presenting their addresses find things to say that are very well worth saying. Part of the reason, no doubt, lies in the tradition that has grown up in that Institution that a president should talk about his own experiences. Few men can be dull on such a subject. Part of it lies in the fact that a man is unlikely to reach the Chair unless he possesses certain high qualities ; though it is to be added that since the supply of such men is limited, presidents are rather like beer, all of them are good but some are better than others ! The inspiration of a very special occasion must account for something, too. How few amongst presidents, surely, must be those who have left the preparation of an address in the hands of an assistant ! But the major factor that leads to addresses of such high quality is, probably, that in attaining to the Chair most presidents have reached a pinnacle of their ambitions. They no longer need to fear that to offer an unusual opinion will bring down ridicule upon them, that they will be labelled " unsound " if they venture to speculate, or that their reputations will be damaged if they support unpopular causes. They can give free rein to their thoughts, knowing that their fellows, having elected them to presidency, will value their opinions ; and they can gain confidence thereby, not to treat the address lightly—indeed, no !—but to believe that a thought well and truly digested in such minds as theirs, even if it leads to provocative or unwelcome conclusions, must still be valuable and well worth expressing.

The point is well brought out in the address of Mr. P. L. Jones, presented last Friday at the Mechanicals and reprinted in a very full excerpt elsewhere in this issue. His theme was so well worn that it might have seemed one on which there was nothing more that could profitably be said; that the author of such an address must be doomed to be merely repetitive of others. Let those who think so read the address ! It is, of course, true that there is little in it with which marine engineers are unfamiliar. But Mr. Jones very well appreciated that he was addressing an audience not of marine engineers but of mechanical engineers of every sort and kind. He set out to do, in fact, what it seems to us grows more and more valuable the further outwards the bounds of engineering specialisation are pressed. He interpreted to other engineers the peculiar qualities that the practice of marine engineering demands; and in doing so he broke away from beneath the feet of critics the very grounds on which they base allegations of undue, stick-in-the-mud, conservatism in marine engineering practice. He explained to the land-lubberly some of the fundamental reasons wherein engineering at sea differs from that on land. It is curious how blind we can all be to other people's problems. That blindness seems very nearly to have once affected Mr. Jones himself. For, as he reveals in his address, his move, not long after the first world war, from Metropolitan-Vickers to Swan Hunter and Wigham Richardson, Ltd., seemed to him at that time possibly a retrograde step, a step from an enlivening atmosphere of exciting advancement into a much more conservative field. How different he found the truth to be ! Perhaps we should say how effectively he (and others like him) were able to alter the truth ! For in fact he found that it was not mere aversion to change but hard-headedness, not lack of initiative but true appreciation of marine necessities that, temporarily, in the twixt-war years delayed advance. Hard sea experience had forced upon ships' owners and marine engineers the realisation that the degree of reliability essential at sea was far above that which would be fully satisfactory on land. But combined with this hard-headedness there was still a readiness to make experiments and a determination to find the means of raising the reliability of such things as gears, condenser tubes and high pressure plants, troubles with which were holding back advance.

Another of the president's points should also make the critics hesitate. It is simple enough in many other spheres of engineering endeavour to determine almost anything by experiment should the need justify it. But we cannot put a full-scale ship into a ship tank ! It must be tested at sea, which implies, since the sea is infinitely variable in its moods, and no one ship identical with another, that no one test is strictly comparable with another. How devastating the uncertainty thus introduced can be, is illustrated by the fact that " some builders claim that the all-welded hull requires 15–20 per cent less power than a riveted one of the same dimensions, whilst others, equally experienced, put the figure at not more than 5 per cent." Again, until Pametrada came into being there was no means, except at sea, of testing marine turbine machinery. Even to-day propellers can be tested only in model form and correlation with full-scale service must remain uncertain until a full-scale test plant becomes available. But, naturally, in view of the very great expense marine engineers and shipbuilders hesitate to build such a plant. They hesitate all the more because, in theory, the performance of a full-scale propeller should be predictable from the model. But is it ? A similar problem of correlation between ships' models and full-scale ships led up to the " Lucy Ashton " trials which, though very expensive, have undoubtedly justified their making. In marine engineering, more completely than in any other field of engineering endeavour, much practice has to be based not on exact measurements but upon experience ; and often in making measurements there is no certain means of disentangling from the whole the relative importance of separate factors. How valuable it is to be able by carefully controlled tests to reduce the variables to unity has been abundantly proved in many other fields. The fact that so often it is impossible or else immensely costly in marine practice, adds to one's respect for those, Mr. P. L. Jones amongst them, who have, nevertheless, raised marine engineering in more recent years to a status of advancement comparable with that in any other field.

A Seven Day Journal

Institution of Mechanical Engineers

THE annual dinner of the Institution of Mechanical Engineers was held on Thursday of last week at the Dorchester Hotel, London. In proposing the toast of "The Institution," the Marquess of Salisbury, Lord President of the Council, remarked that nuclear fission would have a similar effect on the twentieth century as the steam engine had on the eighteenth, and electricity on the nineteenth centuries. Initially, atomic energy was regarded as a destructive rather than a creative force, but, like other discoveries which had been advanced by the needs of war, such developments had, he said, now been diverted to more beneficent purposes. Nuclear power was now a supplement to coal which was a dwindling asset, and becoming more difficult to produce, which, he continued, linked with increasing price was directly affecting production costs and exports. The Lord President pointed out that since coal production was almost static and that oil for physical reasons could not meet the deficiency then it was upon the development of nuclear power that our ability to maintain industrial prosperity and our standard of living depended. The efficient application of nuclear power to industry depended upon engineers and he noticed with satisfaction the courses being run at Harwell which would help to spread knowledge and help our engineers to employ their skill in adapting this new source of power. Mr. P. L. Jones, the president of the Institution, replied and considered the possibilities and dangers of nuclear power in marine engineering. He suggested the adoption of a nuclear reactor in association with a high-temperature gas turbine, and appreciated that bunkering problems would no longer exist. Mr. T. A. Crowe, vice-president proposed the toast of "Our Guests." In his response Sir Christopher Hinton hoped that the development of atomic energy plant would be just as well planned as the locomotive industry. He was careful to emphasise that much of the equipment of the new nuclear power stations was conventional in character and conformed with general engineering technique and that the remainder was very much a question of adapting existing techniques to a new power medium. It was difficult to foretell the future uses of atomic energy, but he thought that the immediate trend would be towards reducing the present high weight per horsepower ratio, as applicable to land stations, so that this source of energy could be made available to ships, locomotives and eventually aircraft.

Cromwell Road Extension

ON October 24th, Mr. John Boyd-Carpenter, the Minister of Transport and Civil Aviation, inaugurated work on a 1400 yards section of the proposed Cromwell Road extension. This work will cost about £200,000, and form part of a proposal for an approach to the West End of London from the Great West Road. The Middlesex County Council will be the Ministry's agents for the scheme. The scheme was initiated originally in 1936 and stopped by the war, but was revived in 1954 to an improved plan, we are informed. The Ministry's part of the scheme, in Middlesex, will be about 2 miles long and will terminate at the junction of Chiswick High Road and the Great West Road, where a large flyover will be constructed. The scheme will be carried out in sections under separate contracts. The section on which work has been started by Fitzpatrick and Son (Contractors), Ltd., runs from Dukes Avenue to the District Railway, east of Wellesley Road, Chiswick. Work on this section was interrupted by the war. It will now be completed by the provision of dual carriageways, each for three lines of traffic throughout. The carriageways will be constructed of reinforced concrete with an asphalt surface. There will be footways on both sides of the new road, and a number of pedestrian subways will be provided. It is expected that the whole scheme, with the exception of the flyover at Chiswick High Road, will be completed by 1959. Sections of the road will be used before this date, however, as the work progresses. The flyover will have two carriageways, each capable of taking two lines of traffic. It will take east-west traffic over the Chiswick High Road and slip roads will link the new road with an improved roundabout at ground level, which will distribute traffic to the surrounding road system including the North Circular Road. Details of the flyover are being worked out, the Ministry informs us, with the latest traffic requirements in mind. The part of the scheme from the county boundary eastwards to Kensington is the responsibility of the London County Council. The section between Warwick Road and North End Road was completed before the scheme was closed down during the war. In April this year the London County Council started work on the section between the county boundary and Hammersmith Bridge Road. Work is progressing well and this section should be completed by about April, 1956.

Lloyd's Register Shipbuilding Returns

THE shipbuilding returns for the quarter ended September 30th have been issued by Lloyd's Register of Shipping. In Great Britain and Northern Ireland the steamships and motorships under construction totalled 346 ships of 2,147,057 tons gross, an increase of 65,523 tons over the previous quarter; of this total 95 ships of 596,491 tons were fitting out, the remainder being still to be launched. During the quarter 80 ships of 361,937 tons were commenced, 59 ships of 322,437 tons were launched, while 71 ships of 304,002 tons were completed. Of the total tonnage under construction some 98 ships of 756,286 tons, or 35·2 per cent, were for registration abroad, and 79 ships of 993,963 tons, representing 46·3 per cent, were oil tankers. The tonnage of ships for which plans have been approved totalled 1,326,156 tons, and is the first check in the fall from the peak of 2,684,263 tons in September, 1952. The corresponding proportion of oil tankers in the total was 42·5 per cent and 61·3 per cent. The work in hand abroad amounted to 1033 ships of 4,138,642 tons and was 119,642 tons more than the previous quarter. The ships commenced amounted to 295 of 1,038,333 tons, and those launched totalled 266 ships of 797,230 tons, while the total completed numbered 266 ships of 889,591 tons. Oil tanker construction at 146 ships of 1,789,035 tons was 154,225 tons less than at the end of June last and amounted to 43·2 per cent of the total tonnage building. Throughout the world 1379 steamships and motorships of 6,285,699 tons were under construction, of which the share of Great Britain and Northern Ireland was 34·2 per cent. The total showed an increase of 185,165 tons over the previous quarter. Oil tanker construction in the world amounted to 225 ships of 2,782,998 tons, or 44·3 per cent of the total of ships being built. Of the merchant ships under construction throughout the world, a total of 3,951,698 tons, or 62·9 per cent, were being built under the inspection of Lloyd's Register.

Industrial Safety Week

THIS week special emphasis is being given throughout industry to the necessity for greater care about safety precautions. This "safety week" is sponsored by the Royal Society for the Prevention of Accidents. The society has pointed out that 6,000,000 minor and major accidents have been occurring in industry each year, 800 of these accidents proving fatal. It is urged that by encouraging managements to provide safe working conditions and by training workers in safety methods, these figures can be greatly reduced. During this week there have been poster campaigns, safety exhibitions, talks, film shows, and sound and television broadcasts, all aimed at encouraging workers throughout industry to "start a safety habit." The Royal Society for the Prevention of Accidents has prepared a special leaflet entitled "How to Last a Lifetime," which contains a series of cartoons depicting the kind of faults which quickly lead to accidents. This leaflet says, "whether you work at a desk or at a bench, on the ground or on scaffolding, you have a responsibility for your own safety and for the safety of others. The great advantage of a well-established safety habit is that it lasts a lifetime; it is also a fine example to every young person and newcomer who starts work in your factory." An important event in this Industrial Safety Week is a conference at Guildhall, London, which is being held to-day under the patronage of the Lord Mayor of London. The Minister of Labour, Sir Walter Monckton, Q.C., is among those who are addressing the conference.

Switchgear Laboratory

AT the Blantyre factory of Belmos Company, Ltd., Belshill, Lanarkshire, on Monday last, Dr. S. Whitehead, director of the British Electrical and Allied Industries Research Association, opened a new research laboratory. The laboratory is intended to perform the testing of existing contactors and research work to precede future designs. The principal equipment is a short circuit plant designed to momentarily overload (at 9·2MVA) an alternator. The alternator, a three-phase, 625kVA machine, running at 750 r.p.m., is driven by an induction motor through reduction gearing, and polar inertia is so high that it is not in all cases necessary to disconnect the motor when short circuiting the output. A separate exciter has facilities for field forcing during the actual test, and an exciter on the main shaft can provide dynamic braking. A master breaker protects the set from prolonged overload if the apparatus under test fails to open. The load is applied by a rapid closing switch at any required point on the output waveform; reactors and resistors are present to give command of power factor. At the opening of the laboratory the set was run at low power to produce a series of spectacular arcs. The events of any test are recorded photographically by a twelve-channel electromagnetic oscillograph; plug-in access is provided to instrumentation points throughout the circuits.

Marine Engineering Experience

By P. L. JONES, M.C., B.Sc., Wh.Ex.

In his presidential address to the Institution of Mechanical Engineers, last Friday, Mr. P. L. Jones took as his subject merchant marine engineering. He stressed the need for reliability in marine machinery and showed how this factor delayed the application to ships of engineering advances made in land plants. He referred to the work of various research organisations and discussed oil engine machinery as well as steam. In a reference to the design of propellers he pleaded for full-size testing equipment, believing its great cost would be soon repaid. In conclusion he referred to those factors that set a limit to the speeds at which ships operate. Below we print long excerpts from the Address.

THE organisation with which I am associated has been engaged in shipbuilding and marine engineering for over 100 years. It owns three separate shipyards and three distinct works in which machinery is built; in addition, it has three repair yards, each having facilities for dry-docking ships. The engineering works not only normally supply the machinery required for the ships built by the group, but all three of them have considerable surplus capacity and supply propelling machinery to other shipbuilders.

Reliability

No engineer needs to be told that machinery must be reliable in operation. This simple statement, however, means much more at sea than on land. In my Thomas Lowe Gray Lecture in 1938 I referred to this matter at some length and stressed its great importance at sea. To-day, I feel, if anything, even more strongly than I did seventeen years ago, that reliability is of paramount importance at sea. Reflecting on the possible consequence of a breakdown I think most people will agree with that statement, and I will not labour it now. I propose, however, to examine briefly some of the implications of this conclusion.

In the early 1900s most ships were propelled by reciprocating steam engines, non-superheated; the Scotch boilers were designed for low pressures, about 180 lb per square inch, and they were usually hand fired with coal; even hot forced draught was still to come. This state of affairs had remained unchanged for some years, the principal reasons being that coal was cheap and labour not only cheap but plentiful. The machinery was reliable and gave little trouble and no one seemed to care very much that the thermal efficiency was only approximately 10 per cent.

The growing popularity of the turbine on land, however, and its obvious suitability for certain types of ship, soon resulted in attempts to introduce it at sea, and some important ships, including the "Mauretania" and "Lusitania," completed in 1907, were fitted with direct-drive turbines. While these machines were satisfactory mechanically they were very expensive in fuel. This was, of course, due to the fact that as the turbine is a high-speed machine and the propeller an essentially low-speed device, neither operated at good efficiency, and the overall performance was, in consequence, extremely poor. This difficulty was overcome by the introduction of gearing, and the resulting improvement was so great that a large number of ships with geared turbines were built in the early 1920s. Troubles with fractures of gear teeth soon developed, however and, when corrosion of turbine blades was also experienced, the marine turbine received a setback from which it took years to fully recover. On land some failures would have been expected and accepted as being in the natural course of events, but at sea reliability is the prime necessity and if geared turbines could not be made reliable without delay, out they must and did go. It was not until the design and manufacture of gears was immensely improved and corrosion-resisting materials for turbine blades became available that the geared turbine again came into favour in marine circles.

Land turbine designers were, meanwhile, continually raising the steam conditions to obtain higher economy. Now economy, again, is more important at sea than on land; not only is there the direct saving in cost of fuel, but the more efficient ship requires less bunkers, and that in turn means a smaller and cheaper hull. High steam conditions, of course, involve water-tube boilers, and these were adopted at once on land. This development was, however, completely held up at sea, not because satisfactory marine water-tube boilers could not be built, but for a quite different and simple reason—that is, corrosion of condenser tubes. This was for many years a very troublesome matter, and often had serious and sometimes disastrous effects in water-tube boilers due to contamination of the feed water. An immense amount of investigation on this subject was conducted by the Corrosion Research Committee some thirty years ago, but it was only after the development of new materials, such as aluminium-bronze, cupro-nickel, &c., that sea-water corrosion of condenser tubes was definitely overcome. Once this position had been reached, however, and reliability re-established, steam conditions at sea became rapidly more and more in line with land practice and, in fact, several ships were at sea in the 1930s with pressures and temperatures higher than in any land power stations of that time.

Gas reheating has been adopted on a few ships, and for the same reasons as those that apply in land practice, that is, not only to increase the thermal efficiency, but also to minimise the wetness of the steam in the low-pressure stages and consequent erosion of blades. This scheme involves leading the steam exhausted from the high-pressure turbine back to the furnace where it is reheated before being returned to the intermediate-pressure turbine. The thermal advantages realised, however, are offset at sea by the great complication of pipe arrangements and the difficulties of manœuvring. It is for these reasons that gas reheat is not popular in marine circles and it is important to note that neither of these objections apply in land turbine practice.

Steam reheat has been adopted on some ships, but the resulting small gain in efficiency is, generally speaking, not considered worth while in marine turbine practice.

Gearing

The great developments in gearing for marine turbine installations have been very adequately dealt with in recent years and there is an extensive literature on the subject. The present position is that, as a result of greatly improved production, due to much more accurate construction of gear-cutting machines, hobs, &c., post-hobbing processes, such as lapping, shaving, &c., and much greater attention to alignment and lubrication, it is now possible to adopt with safety considerably higher tooth pressures than were previously allowed. This results in great reduction in weight and space and, to some extent, in cost.

In view of the very wide application of gearing to marine steam turbine practice, some people are surprised that gearing of oil engines has not been adopted more widely. The reasons, however, are quite simple. The direct-drive turbine was not only prohibitive in cost and weight but, as previously mentioned, extremely inefficient, and the turbine would not have survived in general marine practice without gearing. With the oil engine, however, gearing, while reducing the weight, does not produce an improvement in economy; in fact, owing to the losses in the gears and couplings, there is a reduction in efficiency of some 5–6 per cent. In some cases this loss is partly offset by the fact that the propeller efficiency is higher because a lower speed of revolution can be adopted. However, with fast-running oil engines, the fuel consumption per brake horsepower is usually appreciably higher than with slower running machines and, in consequence, the geared oil-engine ship requires to carry more bunkers and this offsets, to some extent, the saving in weight. At the present time the cost of the geared oil-engine is considerably higher than that of direct-drive. This disadvantage may be overcome if the speed of the engines can be sufficiently increased and their weight thereby correspondingly reduced. The great advantage of gearing oil engines is the reduction in head room thereby achieved, which is an important consideration in some types of ship. Having regard to all the above, however, and the advent of the gas turbine, it is doubtful if there will be a great future for the geared oil engine.

Marine and Land Practice

Some engineers, while agreeing that marine engineering practice is now on the same plane technically as that on land, seem to consider there is nothing remarkable about this, and are merely surprised that the position took so long to achieve. It is, however, important to realise the special difficulties with which the marine designer has had to cope and how much more intractable they are than those met with on shore. There are many important points in which land practice differs appreciably from that at sea, for example, whereas few engines of any size in land installations run for more than a few hours on end, it is quite common at sea for machinery to run at approximately full power for days and sometimes for weeks without stopping. One ship of which I have knowledge once completed a voyage of forty-nine days without a stop, and during this period experienced seven full gales.

Some of the requirements of marine machinery are much more exacting than those on shore; few, if any, large land machines are required to reverse or manœuvre frequently; this fact alone has an enormous influence on design. The unidirectional land turbine presents many problems, but it is obvious that it is a much more difficult matter to design a machine which must be able to run at any speed desired, in either direction, at very short notice. The same remarks apply to oil engines and other internal combustion engines. In some marine installations, of course, the main engine is so

arranged that it operates continuously in one direction, such as electric drive. Although this is an important advantage it is usually more than offset by the disadvantages involved in the transmission ; not only is the overall efficiency less but the cost and the weight are considerably greater than with direct drive. Comparatively recently other methods of dealing with this question of reversibility have been evolved, for example, propellers having adjustable pitches, or arrangements of hydraulic couplings whereby the direction of rotation of the propeller shaft is determined by bringing into operation either the ahead or astern coupling at will. These devices may appear quite simple and, indeed, obvious developments, but I can assure you that both of them involve very considerable difficulties in design.

Most land engineers are acutely aware of the necessity to reduce machinery weight to the absolute minimum. At sea this is even more necessary as the weight saved also has direct bearing on the payload of the ship. This is one reason why supercharging of oil engines is being increasingly adopted in marine practice.

The space occupied by machinery is also a continual problem for the marine-engine builder. He is always being pressed to reduce it in every possible way. This introduces all kinds of difficulties. There is, for example, often insufficient room to introduce large bends in high-temperature pipe arrangements and, in order to avoid unacceptable stresses the necessary flexibility has to be obtained in other and less satisfactory ways. The land engineer is much more favourably placed in this respect. It is not an exaggeration to say that a great proportion of the time of many able marine engineering draughtsmen is spent in trying to fit a vast number of components into an extremely small volume.

Another point of considerable interest is that the ship is continually and often violently on the move. This involves very special precautions, because the machinery components must not only be fixed effectively, but also require to be carefully positioned. The importance of effective drainage is well appreciated by all experienced engineers ; it is, however, often very difficult to achieve in a ship which may roll many degrees or pitch heavily at any time. Consider, for example, the condenser extraction pump. In land practice this may be placed almost anywhere within reason, but in a ship it must be near the fore and aft centre-line of the condenser, otherwise the head on the pump may be entirely eliminated under certain conditions, with the possibility of serious results. These are merely examples to illustrate the problems of the designer but there are a host of other points of similar nature which have to be taken into account.

Notwithstanding all these difficulties, at the present time the efficiency of some marine installations is at least as good as that of most land installations of comparable size. In some recent ships in which the power is only 8000 s.h.p. the thermal efficiency realised in service is over 25 per cent, which is extremely satisfactory. As regards oil engines the efficiency is of the order of 37–38 per cent, and nothing yet achieved on land can surpass this.

Trying out New Ideas

One of the great difficulties in shipbuilding and marine engineering is getting new ideas tried out. This can only be done really effectively on actual ships, and ships are expensive things with which to experiment. Nevertheless, certain projects have been investigated in this way. To cite one example, some years ago, a revolutionary design in propellers was brought out and my firm were sufficiently interested to decide to give it a full-scale test. It was agreed with the owners of a ship at that time nearing completion, that the sea trials should first be run with a propeller of normal design and afterwards with one of the new type. This involved considerable time and expense. Apart altogether from the cost of the second propeller it was necessary not only to dry-dock the ship after the first trial so as to change the propeller, but also to postpone the second trial several days until the weather was approximately the same as that experienced on the first one, otherwise the results obtained would have been worthless as a comparison.

This leads to a very important conclusion. Perhaps the greatest disadvantage with which the marine designer has always had to contend is that of obtaining reliable observations. Only those who have been to sea in adverse weather can realise fully how difficult this matter can be. Not only are conditions very unsatisfactory for the operating staff, but the instruments themselves are often quite unable to stand up to the arduous conditions imposed on them. All engineers will, I am sure, at once agree that the absence of reliable data is a handicap of immense importance, but adverse weather is not the only difficulty in this connection. Even in trial trips carried out under so-called " fair weather conditions " and with many experts aboard armed with apparatus specially designed to take certain observations, it frequently happens that some of the data obtained are of little or no value. In the first place this is because trial trips are usually run with the ship in the unloaded condition. The propeller is therefore not sufficiently immersed and will not absorb the shaft horsepower at the designed revolutions per minute. Further, the ship may be trimming too much by the stern and the results obtained will bear no relation to those existing with the ship fully loaded on an even keel. Of recent years, however, under the ægis of the British Shipbuilding Research Association, and with the co-operation of certain shipowners, observations have been taken on loaded ships in service operation. When sufficient data of this kind have been collected this may well be of real importance to shipbuilders. In the second place, sister ships built by the same shipyard and to the same drawings and running trials under substantially the same weather conditions, will sometimes give performances which may differ by as much as 5 per cent. This could be due to a variety of causes, but recent researches point to variations in roughness of the hull as one of the principal reasons. New ships are, of course, usually dry-docked just previous to the acceptance trials and the surface of the hull is in " good " condition, but considerable differences in roughness may still exist. In this connection the work done by B.S.R.A. a few years ago on the ship " Lucy Ashton " is of extreme importance. This ship was arranged for propulsion by jet engines and the resistance of an actual ship was measured for the first time with accuracy. Valuable data have been obtained from these trials and the correlation between a full-size ship and model tests established.

An immense amount of research and investigation of the problems of observation by very able people has certainly helped matters. The accurate measurement of shaft horsepower and thrust is, however, still difficult to ensure, and conflicting results continue to be observed which are incapable of explanation. One instance will suffice to pin-point this. Although welded ships have been built in large numbers for many years (my firm built completely welded ships over twenty years ago) there is still a wide divergence in views as to the relative resistances of welded and riveted hulls. Some builders claim that the all-welded hull requires 15–20 per cent less power than a fully riveted one of the same dimensions, while others, equally experienced, put the figure at not more than 5 per cent. It is perhaps fortunate that this particular question which has also been the subject of exhaustive research in recent years may soon be a matter of academic interest only. It is probable that before long all ships will be largely welded, not indeed because welding is necessarily in every way superior to riveting, but because sufficient riveters will not be available. For this reason most shipyards are already laid out, or are in process of being reorganised, for prefabrication. Large portions of the hull, up to 40 tons in weight, are welded in shops specially designed for the purpose and lifted *en bloc* on to the building slip. It is expected that with this arrangement it will be possible to build the same number of ships with approximately half the number of slips.

The role of the classification societies, Lloyd's, British Corporation Bureau Veritas, &c., in the 1920s, was very different from what it is to-day. These bodies, and especially Lloyd's, have had an increasing influence, particularly from 1925 and the subsequent twenty years or so, and many very important investigations have been initiated and carried through by them. A great deal of such work is now the province of B.S.R.A. and Pametrada, both of which bodies were initiated and largely financed by the shipbuilding industry some ten years ago. The present time, in fact, can be regarded as the age of co-operative research in the marine field, almost all the shipbuilders in the United Kingdom being members of one or both of these bodies. This set-up has many good points, but it also has others which are not so satisfactory. It is rather like putting too many eggs in one basket, and it has had the effect of reducing to some extent individual initiative in research and design. On the other hand, it has probably saved many millions of pounds by eliminating useless and duplicated effort and over-intense competition such as that which was so characteristic of the shipbuilding industry in the 1920s. To cite one example, the Brown-Curtis, Parsons, Metropolitan-Vickers and other types of marine steam turbine, which were so fiercely competitive in those days, have now been replaced almost entirely in this country by turbine designs produced by Pametrada. This body has the enormous and, as far as the United Kingdom is concerned, the quite unique advantage of possessing facilities enabling steam-turbine machinery of high power to be tested not only under full power, but also with the designed steam conditions. Owing to the immense cost involved in providing the necessary boiler plant, testing equipment, &c., for this purpose, this had never been possible in this country before Pametrada was initiated. In consequence, the actual performance of marine turbines had always been extremely difficult to establish and the effects of small changes in design almost impossible to assess. This unsatisfactory state of affairs has now been rectified.

Oil Engine Developments

As regards oil engines, however, the development has been along different lines. It was comparatively easy to test these engines thoroughly at full power in many marine engine establishments, and it is due almost entirely to that fact that oil engine

designs improved rapidly at the same time that marine turbines were making little real progress. In the United Kingdom the majority of engines now being built for ocean-going ships are of the opposed-piston type. Some people have difficulty in understanding why this particular design has become so universally popular because at first sight it appears to be an unnecessarily complicated arrangement. However, its advantages are many, and once it had been established that it was a reliable proposition there was nothing to stop it. It owes its satisfactory position chiefly to its extreme reliability in operation, high thermal efficiency and the great ease with which overhauling can be carried out. Another advantage is the absence of cylinder covers, the design of which has always presented great difficulties in engines of more conventional type. A further point is that the volume of the combustion space for a given diameter of cylinder is approximately twice that of the normal engine. Moreover, as the scavenging air is introduced at the bottom of the cylinder and exhausted at the top, not only is the scavenging efficiency very high, but the shape of the piston head can be made independent of the scavenging process. The form of the combustion space can therefore approach the ideal—that is, that of a sphere—thereby resulting in high combustion efficiency. Furthermore, as it is not necessary to have a large surplus of scavenging air in this engine the temperature of the exhaust gases for a given mean indicated pressure is higher than that in other designs, and this not only increases the mechanical efficiency, but also results in greater availability of the heat in the exhaust gases for producing low-pressure steam for ancillary purposes. It is, however, important to note that all these favourable features would have been of academic interest only, if reliability had not been first achieved.

Vibration of Ships and Machinery

Vibration has long been a subject of intense interest in all branches of engineering. It is true to say, however, that most phases of this subject with which the land engineer is familiar, are met with at sea, and, in addition, there are many other aspects which are peculiar to the marine field.

When considering a new ship, the power and rating of the engine having been decided, the engine builder then has to make a provisional selection of the most suitable engine for the specified requirements. This involves, among other things, the choice of propeller revolutions. Before going any further it is then necessary to carefully consider the possibilities of hull vibration. An engine may run on the test bed with absolutely no trace of vibration and yet the ship may be unsatisfactory in operation. Ships are elastic structures and there are a variety of ways in which they can vibrate. There are whole-ship vibrations and localised vibrations. Whole-ship vibrations can take place vertically in many different configurations—that is, with different numbers of nodes and corresponding frequencies. Ships can also vibrate horizontally and, in addition, they can vibrate torsionally. The water near to the ship plays an important part in all whole-ship vibrations. In the first place, some of the water moves with the ship, and the frequencies of vibration, therefore, vary with the loading and the draft. In the second place, the friction of the water acts as a damper.

The frequency of the fundamental or two-node type of vertical vibration for most ships ranges from about seventy to 100 per minute, which happens to be just the range of propeller revolutions per minute usually adopted in single-screw ships for the highest economic efficiency. The two-node horizontal vibration frequency is usually 40 to 50 per cent higher than the vertical two-node type, and the three-node vertical type about 30 per cent higher still.

It is often a matter of great difficulty to steer clear of these frequencies as the engine revolutions per minute must be chosen so that there is no likelihood of synchronism or near synchronism with any of the more important of them. Little can be done to correct matters in this connection after the ship is built. An immense amount of work has been done in this and cognate problems in the last thirty years, and whole-ship natural frequency vibrations can now be calculated with some degree of accuracy at the design stage, but, having regard to all the possibilities, it is indeed remarkable that so many ships are, for all practical purposes, free of vibration.

Vibrations of propelling machinery are in a wholly different category. Many engines are very nearly, if not completely, balanced both horizontally and vertically, but torsional vibrations may still be very troublesome. There are many types of torsional vibration, the effect of some of which can be avoided by good design. In land practice it is usually only necessary to ensure that there is no natural vibration frequency near the running speed of the machine, which is usually of constant speed ; at sea the engines have to run at various speeds.

The calculation of torsional vibration frequencies presents little difficulty, but the estimation of the stresses which may be set up due to synchronism, or near synchronism, of these frequencies with those of the applied forces is a very involved matter. The stresses produced by vibrations which cannot be avoided can be minimised in practice by the fitting of vibration detuners and/or by adopting a " barred " range in speeds. There is now an enormous literature on this subject, but thirty years ago, while a good deal was known about torsional vibrations of geared turbine installations, there was little knowledge available on oil engines and the stresses which such vibrations might set up in them. About that time, I became interested in a very important case. The crankshafts of both four-cylinder engines in a twin-screw motorship failed owing to the fact that the seventh harmonic of the engine revolutions per minute was in near synchronism with the second degree natural torsional vibration frequency of the system. I might say that it was at that time a great surprise to the designers of this engine that such a fact could have serious effects on a four-cylinder machine. I was asked to investigate this matter and I got great help from a paper which Professor F. M. Lewis read before the Society of Naval Architects and Marine Engineers in November, 1925, and which it happened I had just previously read. He went into the matter very fully and I found his work of great value. It is now a matter of routine to investigate these problems in every individual case, but twenty-five to thirty years ago this was very far from being the position.

Ships' Fuels

During the last forty years there has been a complete transformation regarding fuel in the marine field. In 1914, 97 per cent of the world's ships were burning coal ; in 1939 this figure was 45 per cent, and to-day it is 11 per cent.

Up to a few years ago oil engines used diesel oil almost exclusively. Twenty to twenty-five years ago heavy oil had been burnt successfully in marine oil engines, but the practice did not become common. This was not because it was unsatisfactory, but because the price differential at that time between heavy and diesel oil was not sufficiently attractive. It was found then, as now, that although oil engines could burn heavy oil perfectly well, the wear of the liners, piston rings, and maintenance generally were appreciably greater with the heavy oil, and with the low difference in price of fuel the advantage was small. At the present time the price differential is between £4 and £5 per ton, and, in consequence, shipowners naturally insist on burning heavy oil notwithstanding increased bills for maintenance and renewal of parts. It is now almost universal practice to arrange for heavy oil in motorships. This has, of course, inspired further efforts to increase the efficiency of steam installations, and several very economical steamships have recently been put into operation. The adoption of heavy fuel for the oil engine has, however, undoubtedly given it a fresh advantage over all its rivals.

It was said some years ago that it is a crime to destroy valuable coal by burning it in boilers, and there is no doubt a good deal of truth in that remark. However, I admit that I am old-fashioned enough to have some regrets for the passing of coal at sea. The firm with which I am associated built, as recently as 1940, several high-class coal-fired, twin-screw, passenger steamers. These ships were provided with steam turbines and water-tube boilers mechanically fired. They were intended to operate on inferior Indian coal having a calorific value of only 10,000 B.Th.U. per pound. All the auxiliaries were electrically driven by turbo-generators and, although the total power was only about 9000 s.h.p., on two screws the thermal efficiency reached the satisfactory figure of 21 per cent. These ships gave very good performances for some years with many widely different varieties of coal, but owing to the great increase in price and the difficulties of obtaining supplies, the owners recently decided to convert them to oil burning.

In 1935 we constructed three train ferries for the Continental passenger service of the then Southern Railway. These ships, which operated between Dover and Dunkirk, were also provided with turbines and water-tube boilers mechanically fired. The bunkers were self-trimming and the coal was delivered on board by trucks emptying direct into the bunkers. At no stage was the coal man-handled, and the stokeholds, which were of the closed forced-draught type, were as clean as those of any oil-burning ships I have ever seen. Here, again, after several years of successful operation, the same difficulties regarding the supply of coal led to their recent conversion to oil.

Before very long I have little doubt many marine engineers will have similar nostalgic feelings regarding oil fuel. Oil-fired boilers will be next " on the list," and gas turbines will no doubt be the fashion in the near future. Several ships fitted with gas turbines are now at sea and great developments are in hand. When teething troubles have been overcome and the present difficulties experienced with burning heavy fuel surmounted, there will be considerable scope for the oil-fired gas turbine in the marine field.

All engineers will soon be involved in the application of nuclear fission to the production of energy, and it is certain that the British Nuclear Energy Conference, which has been referred to in the Press and also in *The Chartered Mechanical Engineer* for Sept-

ember, will play an important part in keeping us in close touch with developments in this vital subject.

The use of nuclear energy for marine propulsion is now an accomplished fact, but, so far, the only ships so equipped are the "Nautilus" and the "Sea Wolf." The reactor used in the "Sea Wolf" is of a different type from that in the "Nautilus"; in each case it merely replaces the oil-burning installation in a normal ship, the rest of the machinery being substantially the same as in general marine steam turbine practice.

No doubt, before long, the heat developed by nuclear energy will be transmitted more or less directly to the working substance of a gas turbine. When this is achieved and really high gas temperatures can be accepted with confidence, the overall efficiency will be of a very high order indeed. Nuclear energy will very soon have an enormous effect on the marine field. Apart from the purely engineering side of the matter the naval architect can be expected to take full advantage, for example, of the fact that the weight of the bunkers at the end of the voyage will be substantially the same as at the start. A very important aspect of nuclear energy is that eventually it will, presumably, render the United Kingdom independent of imported fuel. Mechanical engineers are not the only people who will appreciate the implications of that.

Propeller Tests

From the foregoing remarks it may be agreed that the position in the marine field, while leaving a great deal to be desired, has made considerable advances in recent years. There is, however, one item in the marine set-up which I think is in a much less satisfactory situation. I refer to the propeller.

The propeller can be described as the device which transforms the power produced in the engine-room into the thrust desired by the naval architect; it is thus the connecting link between the efforts of the marine engine builder and the shipbuilder. For this reason the design of the propeller is sometimes regarded as within the province of the naval architect and sometimes as the duty of the engine builder. In the particular firm with which I am associated the engine builder is not only responsible for estimating the power required for the desired ship's speed, but he also designs the propeller.

It is common knowledge that a great deal of time and money has been spent in recent years on research on the design of propellers. First-class brains have been devoted to this subject for a long time. A very large number of systematic tests of models has been carried out in various laboratories and tank installations throughout the world, and this work is continuing. No one who has witnessed some of the beautiful and fascinating experimental work of propeller research could fail to be impressed by the enormous amount of skill and ingenuity involved. Nevertheless, at the risk of being considered a complete "Philistine" I will confess that as a practical man I think such work leaves a lot to be desired. It has always seemed to me to be a matter of very grave doubt as to how far the results obtained from a model propeller of diameter 15–20in running at several hundred revolutions per minute can be applied to a full-size propeller of, say, 18ft running at about 100 r.p.m. or less. For many years I have felt there is a risk of considerable error in this practice, and that the shipbuilding and shipping industries would be wise to give very careful consideration to the question of providing the necessary facilities for full-scale propeller tests under conditions as nearly similar as possible to those which exist behind the actual hull. I am aware that the cost of equipping and running such an experimental station would be extremely large, but having regard to the importance of the question it is, I think, quite certain that the money would be well spent. A poorly designed propeller is something which the shipbuilding and shipping industries simply cannot afford. It results in wasteful consumption of fuel and unnecessarily large machinery and bunkers, &c. In many branches of industry the position has now been reached where, after several years of experimental work at enormous expense, further research on any particular detail is likely to produce only a small increase in efficiency. This is the well-known law of diminishing returns. If full-size tests could be adopted, after a period of time the same position would no doubt be arrived at in propeller research, but I believe that before that stage is reached considerable improvement in existing designs would be obtained without much difficulty and without much delay. The great cost of the testing equipment would, I think, soon be repaid and steady improvements in efficiency could be counted on for some years to come.

Choice of Speed and Machinery

The choice of speed for a new ship is influenced by all sorts of considerations, many of which are altogether outside the province of shipbuilders and marine engine builders, and can be properly assessed only by the shipowner. The shipbuilder can inform the shipowner of some of the matters which affect this question, such as shaft horsepower, cost of machinery and hull, fuel consumption, weight and space occupied by the machinery, &c., but it is the shipowner alone who can give due weight to the many other issues involved. One of the special circumstances surrounding the design of ships is the water in which they operate. Ships cannot escape into a more rarefied medium and thereby reduce the resistance to motion. They have always to contend with media of almost the same density, waves of the same average size, winds and currents, &c., which are substantially the same year after year and century after century; they have to plod along in water in which resistance to motion is proportional to the nth power of the speed, where n is always more than 2 and maybe as much as 4. Horsepower is proportional to the speed to the power $n+1$ and fuel cost for a given distance is, of course, proportional to speed to the nth power.

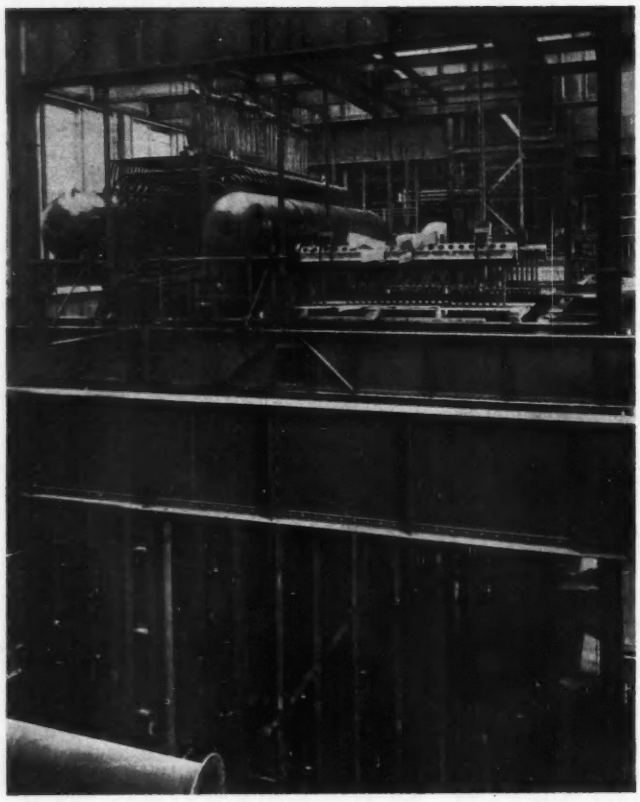
Assuming that the ship's form is as efficient as possible, increased speed can be achieved only by increased power. Higher power means not only larger and more expensive machinery but also heavier fuel cost and increased weight and space and bunker capacity.

All these factors are taken into consideration by shipowners, and the speed finally decided upon is the result of extremely careful and intelligent weighing up of the pros and cons. It is recorded that a famous politician, replying to an awkward question in Parliament, said: "The answer depends on an accurate assessment of several immeasurables." Well, the decision regarding the speed of a new ship is not quite so difficult as that; the issues are not entirely immeasurable but their assessment does require a great deal of knowledge and judgment. Shipowners are usually hard-headed men. They operate their business against world-wide and unrestricted competition, and, as a rule, have very good reasons indeed for any course of action eventually decided upon. The fact that the speed of ships has not shown any spectacular change in recent years is in no way due to failure of naval architects and/or marine engine builders to live up to their responsibilities. They can, in fact, give the shipowner anything he requires in reason, provided he is not only prepared to pay for it but will put up with the consequences in other directions. In land practice the power station is practically unrestricted as regards space occupied and weight, and can have as big a bunker capacity as desired. The shipbuilder is always restricted in all these factors and an increase in any of them results in a reduction in the payload of the ship.

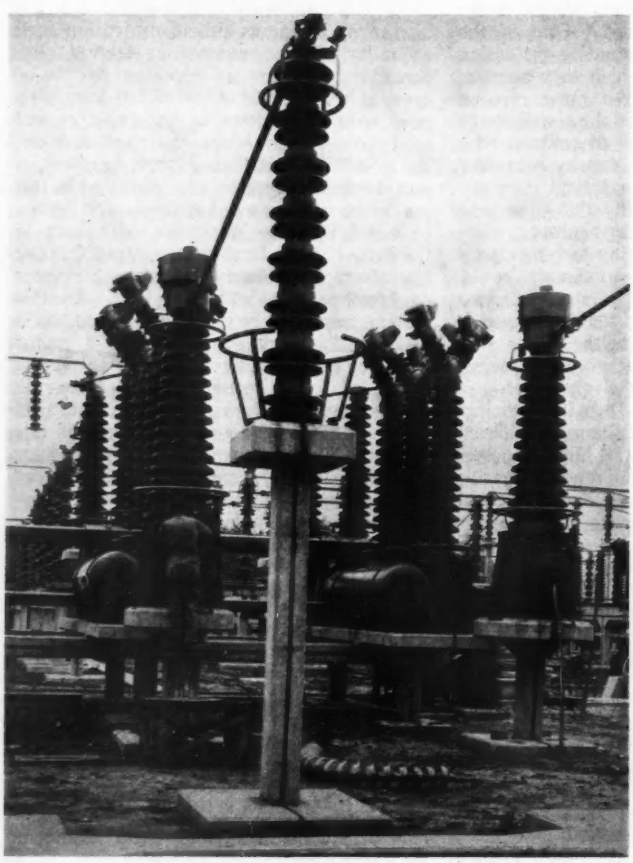
Loose criticism is sometimes applied to the question of choice of machinery. For some ships the problem is an easy one, but in many cases it is not; in a steamship, for example, it is often a difficult matter to decide on the most suitable working pressure and temperature. Some of the economic considerations involved, apart from the costs of the possible alternatives, are fuel consumption, price of fuel at various bunkering ports, proportion of the ship's life which will be spent at sea, itinerary envisaged, designed power, type of personnel available, &c. Surprising as it may seem, investigations show that for certain special trades it would be a better economic proposition to fit the ship with a simple reciprocating steam engine than with the latest type of high-pressure, high-temperature steam turbine, or the most modern oil engine. The modern ship is, in fact, a compromise of conflicting requirements and desiderata and each individual case deserves and usually receives the most careful consideration.

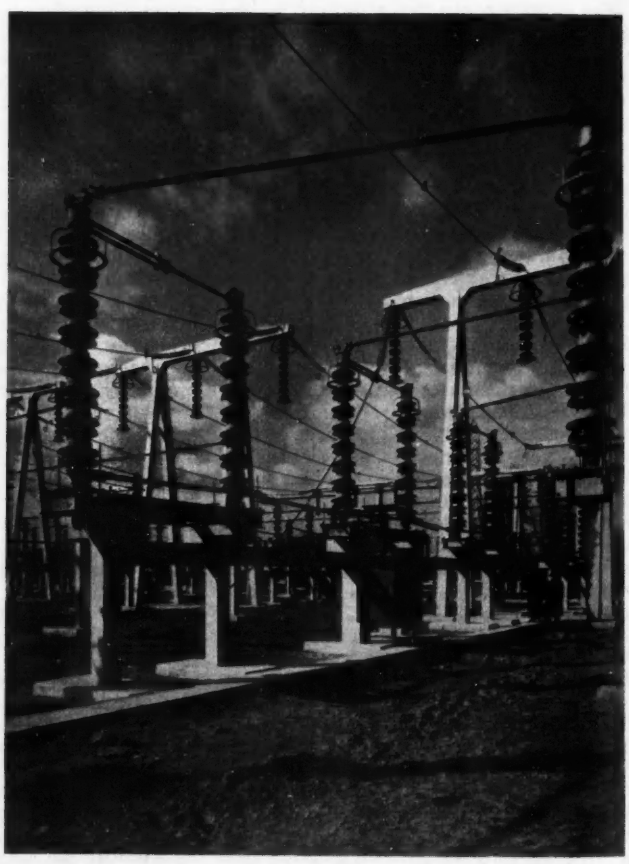
It is a far cry from the plain, simple ship of thirty to forty years ago to the modern marvel, embodying not only all the most up-to-date practice in the engine-room but also many ingenious aids to navigation such as radar, Decca, automatic steering, &c. Streamlining is now an important feature of every ship and great attention has long been paid to such matters as the position and contour of bilge keels, balanced rudders, &c. Stabilising has made great headway in recent years. My firm was interested in this matter many years ago and took out a licence to build Schlick Gyroscopic Stabilisers in the early 1900s. I myself was engaged in the manufacture of a Sperry Gyroscopic Stabilizer at Metropolitan-Vickers in 1922. In this system, immediately the ship starts to roll a small anticipatory gyro starts up a motor which causes the main gyroscope to precess in the required direction to oppose the roll. In this way the roll was, so to speak, stopped before it really got going. Several of this type of stabilizer were fitted in ships later on but, while they were perfectly satisfactory in operation, the system never became popular. It involved a large flywheel revolving at a high speed and it was feared that in the event of a fracture of this wheel the consequences might have been extremely serious and could, in fact, imperil the existence of the ship. The Denny-Brown fin stabilizer, which is now in favour, has no such drawback; it is ingenious and very effective, and is helping to fulfil a long-felt want.

Aluminium Building Sheet.—An aluminium sheet for building work introduced by the Northern Aluminium Company, Ltd., Banbury, Oxfordshire, incorporates a system of "snap" joints. Each sheet has a corrugation running along each edge; during assembly, the corrugations of adjacent sheets overlap, and are formed in such a manner that they snap together to form a weatherproof joint; fixing clips are concealed, generally on the inner side of the corrugations.



Figs. 1 and 2—(Left) 515,000 lb boiler during erection in Drakelow "A" power station. One of the three horizontal superheater stages in the low temperature zone can be seen. (Right) Turbine room: the fourth 60MW hydrogen-cooled turbo-alternator is due to be commissioned this year





Figs. 3 and 4—(Left) Part of the Reyrolle 275kV, 7500MVA airblast switchgear being erected in the supergrid outdoor switching station at Drakelow. (Right) One of the G.E.C. tandem 275kV, 1200A, triple-pole isolators in this outdoor switching station. It is hydraulically operated by remote or local control with provision for local manual operation and its contacts are designed to ensure shattering of ice.

Drakelow "A" Power Station

Drakelow "A" power station, which forms the first part of a 720MW installation near Burton on Trent, was formally opened on October 21st by Mr. J. Eccles, deputy chairman (operations) of the Central Electricity Authority. By the end of this year the four 60MW hydrogen-cooled turbo-alternators should be in commission, together with the associated 515 klb per hour, 1500 lb per square inch, 1050 deg. Fah. p.f. fired boilers. Work has also started on the adjoining station, Drakelow "B," which will house four 120MW turbo-alternators and their unit boilers, each generating 860 klb of steam per hour at 1500 lb per square inch and 1000 deg. Fah., with reheat from 415 lb per square inch and 700 deg. Fah. to 375 lb per square inch and 1000 deg. Fah. The first 120MW is due to be commissioned in 1958.

TWO power stations are being built at Drakelow, about 3 miles south of Burton-on-Trent. The first station, which was formally opened on October 21st by Mr. J. Eccles, deputy chairman (operations) of the Central Electricity Authority, is known as Drakelow "A," and will have a capacity of 240MW, provided by four 60MW generating sets. The second station will be known as Drakelow "B" and will contain four 120MW generating sets, making a total capacity of 720MW on the site.

The whole project provides a good illustration of post-war advances in British power station practice. Each 60MW turbo-alternator in station "A" operates with stop-valve steam conditions of 1500 lb per square inch and 1050 deg. Fah., provided by a 515,000 lb per hour boiler. In the larger station "B" each 120MW set will take steam at 1500 lb per square inch and 1000 deg. Fah. from a 860,000 lb per hour boiler with reheat from 415 lb per square inch and 700 deg. Fah. to 375 lb per square inch and 1000 deg. Fah.

Site clearance for the "A" station was started in May, 1950, the first set was commissioned on December 3, 1954, and all four sets are due to be in service by the end of this year. In the meantime preliminary site work has been started on station "B" where the first of the four sets is due to be in operation before the end of 1958. Drakelow will constitute a key point in the 275kV Supergrid, to which both "A" and "B" stations will be connected.

Early in 1952 we visited Drakelow to see some of the work in progress and in our issue of February 22nd, pages 276, *et seq.*, we published an article describing the "A" station and the main items of plant. To avoid undue recapitulation in the present article, the leading particulars are summarised in tabular form and our description is brought up to date on the basis of information derived from a tour of the station on October 21st.

It may be recalled that the Drakelow site, 3 miles south of Burton-on-Trent, covers an area of 746 acres bounded on the north-east by the Midland Region railway line between Leicester and Burton, on the south and east by the Burton-Tamworth road and on the west by the River Trent, which supplies the cooling water. There are good rail communications with the coalfields of South Derbyshire and Nottinghamshire.

Sand and gravel on the south-west corner of the site have been worked to provide aggregate for concrete in the constructional works and the resulting excavations will be filled in by using them for ash disposal. All the land on the site not required for these and other works is retained for use by tenant farmers.

The main buildings are supported on solid foundations on marl and the material dug from the area occupied by the building was used to build embankments for the railway sidings. Brick-panelled construction was used for the main building (Fig. 5), the turbine-room (Fig. 2) being of reinforced concrete construction and the boiler-house steel-framed. Each of the two brick chimneys is 360ft high and has an inside diameter of 18ft 6in at the top.

The plant layout was illustrated on page 278 of our issue of February 22, 1952. The turbine-room accommodates four turbo-alternators in line and is flanked, at operating floor level, on one side by the c.w. pump bay and on the other (the south-western side of the building) by the turbine-room auxiliary switchgear bay. Feed heating plant is installed between the turbine-room and boiler-house in which the boiler control panels are installed between each pair of boilers at the same level as the turbine operating floor (that is 20ft above ground or basement level). The boiler-house bunkers are installed between each pair of boilers, and the pulverising mills and forced draught and induced draught fans are at basement level. Behind the boilers, in the north-easterly bay of the building, are the electrostatic precipitators.

Dust from the electrostatic precipitators and ash from the boiler hoppers are taken by water sluice to the disposal pits, which are in a loop of the river, about half a mile from the station. Water for this duty is drawn from the c.w. culverts and discharged to the ash and dust sluices by two 100 per cent duty, 3300 gallons-per-minute electrically-driven, horizontal-spindle sluice pumps.

Ash, grit and dust are discharged periodically into the sluicing system which is below basement level in the boiler-house and provides gravity flow from each end towards the centre of the boiler-house and to swirl pits adjoining the ash pump-house. Ash from the boilers and dust from the electrostatic precipitators are carried in separate lines of sluices; those for the ash are lined with renewable cast iron liners and those for the dust are lined with blue brick. There are three vertical-spindle pumps installed in the ash pump-house to raise the ash and dust-bearing water from the swirl pits and discharge it by gravity along an overhead launder to the ash dump. The launder is of reinforced concrete, lined with basalt tiles.

Each of the four steam generating units consists of a radiant boiler, superheater, economiser, air heater, forced draught and induced draught fans, pulverising mills and oil lighting-up equipment. The boiler was described, and illustrated by means of a cross-sectional drawing, in the article mentioned above (page 276, February 2, 1952). A more recent photograph reproduced in Fig. 1 opposite shows one of the boilers under construction. There are three banks of self-draining primary superheaters, one of which can be seen in the illustration, and the secondary superheater is in two pendant banks. The leading particulars of the boiler are included in the information tabulated below.

Boilers:	
Number and rating	4 × 515 klb at 1550 p.s.i. and 1060 deg. Fah.
Furnace, "Lopulco" radiant heat:	
Heating surface, boiler portion	5526 sq ft
Water walls	8885 sq ft
Volume	34,900 cu ft
Superheater, "Melesco," with tilting burners and dampers:	
Heating surface, primary	29,500 sq ft
Heating surface, secondary	5450 sq ft
Economiser, Heenan, all welded:	
Heating surface	39,168 sq ft
Air heater, Howden, rotary regenerative, two per boiler:	
Heating surface, each	62,000 sq ft
P.F. mills, "Lopulco"	Four per boiler
Burners, tilting, tangential firing	Sixteen per boiler
Coal-Handling Plant:	
Belt conveyors, capacity	4 × 120 tons/hr.
Wagon tipplers, side discharge, capacity	4 × 120 tons/hr.
Method of reclaiming coal from store	Transporter
Area of store covered by transporter	112,500 sq ft
Capacity	56,000 sq ft
Turbo-Alternators:	
Number and rating	4 × 60MW
Hydrogen pressure	0·5 p.s.i.g.
Turbine, stop valve conditions	1500 p.s.i.g., 1050 deg. Fah.
Number of cylinders	Three
Number of stages: h.p.	Eleven
i.p.	Nineteen
l.p.	Three

The four 3000 r.p.m. turbo-alternators are arranged longitudinally, with the steam ends of adjacent pairs facing each other and separated by the supervisory instrument panels. Steam expansion takes place in three stages—h.p., i.p. and two outward double-flow l.p. cylinders. Alongside each turbine there are two separate steam chests containing governor valves and a separate emergency stop valve, all of which are operated by an oil pump driven from the turbine shaft. Feed water heating steam is bled from the turbine at six points, and the condensate is heated regeneratively to 430 deg. Fah. at maximum rated output.

Steam from the two exhausts of the low-pressure cylinder flows into twin condensers with a total cooling surface area of 55,000 square feet and requiring 32,600 gallons per minute of cooling water arranged to flow in two passes. Air is extracted from the condensers by three 50 per cent duty, two-stage, steam-jet-operated air ejectors. The associated pumping plant consists of two 100 per cent condensate extraction pumps and three 50 per cent duty, two-speed circulating water pumps, all of which are vertical spindle machines driven by 3·3kV squirrel-cage induction

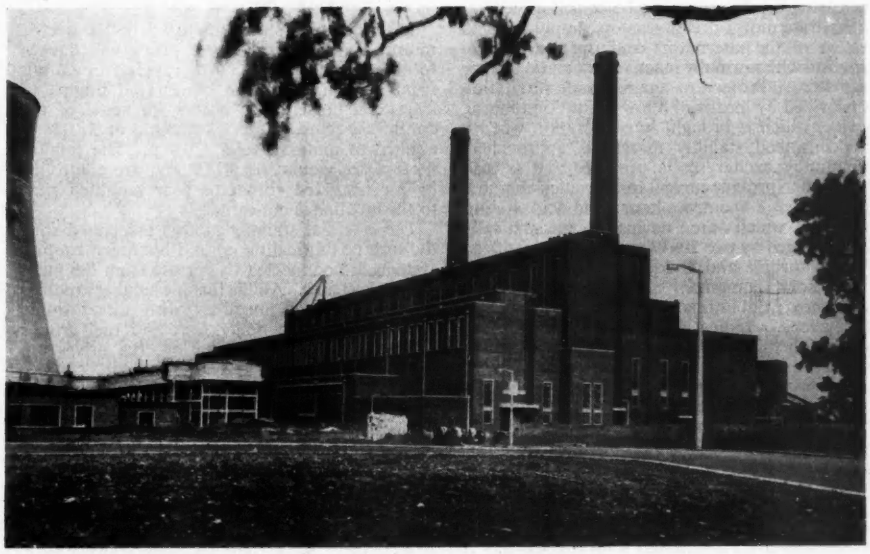


Fig. 5—Drakelow "A" power station as seen from the south. Beyond it, to the north-west, station "B" is under construction. The two stations will have a total capacity of 720MW and they will be connected through switching stations to the 275kV supergrid

motors ; the extraction pump motors are rated at 155 b.h.p. and the circulating water pumps at 455/195 b.h.p. The extraction pumps discharge through the two low-pressure feed water heaters, one of which is a de-aerator, and thence to the feed pump suction main. There are two 100 per cent duty feed pumps for each turbine unit driven by constant-speed motors. Each feed pump can discharge 515,000 lb of water per hour through the four high-pressure heaters and thence to the boiler with a discharge pressure at the pump of 2120 lb per square inch gauge.

Make-up water for boiler feed is obtained from three live steam evaporators, each capable of supplying 25,000 lb of distilled water per hour. The water supply to the evaporators is obtained from the river after treatment in a lime-soda base exchange softening and ammonia removal plant.

The gas control and seal oil equipment associated with the hydrogen cooling system is situated at basement level. The gas control system automatically maintains the density and pressure within the machine and a system of alarms gives a warning of deviation from the required conditions. The hydrogen is supplied in cylinders which are arranged in batteries and connected to a manifold at basement level. Carbon dioxide cylinders are stored for purging the hydrogen from the alternator when necessary. A compressed air supply of the requisite quality is also available to remove carbon dioxide from the casing before access can be gained to it.

Separate motor-driven exciters supply the field system of the alternators and operate in conjunction with normally inactive automatic voltage regulators. Protection against under-excitation is provided by means of a low-excitation limiting device, which is brought into operation when a predetermined stability margin is approached. A standby exciter set is provided ; it is also arranged to provide current for the quick charging of the two 800-ampere-hour lead-acid station batteries which are normally automatically float-charged by two 20kW mercury arc rectifiers.

Each turbine and alternator is equipped with supervisory equipment capable of detecting departures from normal operating conditions and dimensions. Indicating and recording instruments for this purpose are installed on panels which are mounted, one for each generating set, in the space between the steam ends of the adjoining pairs of sets. Accordingly indication and record is given of h.p. and i.p. shaft position, eccentricity, pedestal expansion and vibration, speed and throttle valve position.

Cooling

The circulating water system is designed for a combination of direct and tower cooling. A maximum of about 8,000,000 gallons of water per hour can be taken by the C.E.A. from the River Trent. During the summer, however, when the flow of the river is often below this figure, cooling towers are employed.

Four constant-speed, vertical-spindle centrifugal pumps, with a rating of 2,000,000 gallons per hour, driven by squirrel-cage motors of 525 h.p., are installed in a pump house on the river bank, about 1350 yards west of the station. Four " cup " screens are installed at the intake, whence the water is pumped to the station through twin, reinforced concrete culverts (each 5ft 6in wide by 7ft high), which discharge into the cooling tower pond and conduit system. Direct or mixed cooling, depending on the river flow, can be put into operation by regulation of the appropriate penstocks.

The cooling tower (one of two) is of reinforced concrete, with a base diameter of 240ft and a height of 300ft above pond coping. It is designed to cool 3,820,000 gallons of water per hour through 17 deg. Fah. The existing culverts returning the circulating water to the river run through the site of the proposed " B " station and temporary pipes have, therefore, been installed over this part of the site to allow work on that station to proceed. Considerable hydraulic energy has to be dissipated at the outfall because of the head between the power station and the river. Dissipation of this surplus energy is effected in tumbler bays and the final discharge to the river is made through a discharge chamber fitted with baffles.

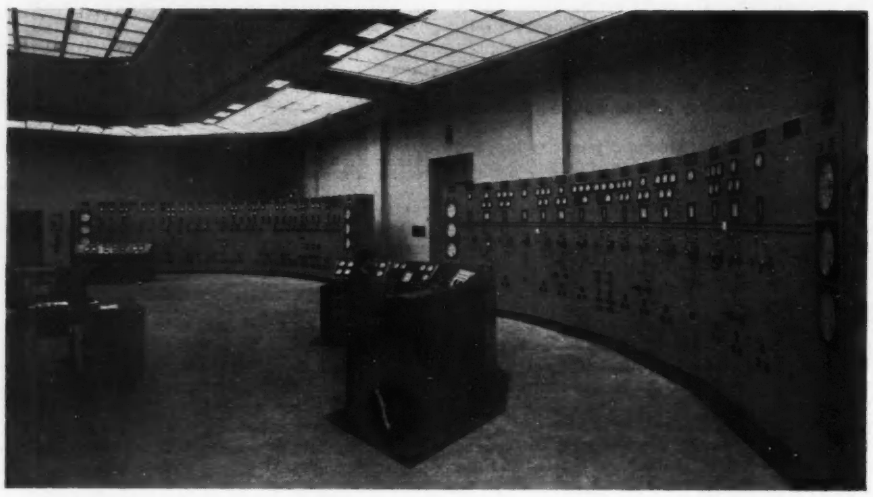


Fig. 6—Control room at Drakelow " A " power station. The generator control desk is in three sections. The central section carries the loading instruction panel and communications equipment. The two wing sections are for alternator operation

Auxiliary Motors and Supplies

In the complete station there will be 700 electric motors for auxiliary drives. They will have a total horsepower of 43,000, ranging in output from 2070 h.p. for the boiler feed pumps to fractional horsepower motors for some of the control systems. Direct switching at 3·3kV is applied to motors above 120 h.p. The smaller motors are wound for 415V and are controlled by air insulated contactor gear mounted next to the auxiliaries concerned.

The essential standby motors associated with the turbine lubricating oil and hydrogen cooling systems are connected to operate from the main station batteries. All the turbine auxiliary motors are squirrel-cage machines with direct-to-line starting. For the boiler fans and fuel groups which require speed regulation, the drives are provided by stator fed Laurence-Scott " N–S " variable-speed commutator motors with induction regulators. Control of the motors is arranged by grouping according to operational functions and is effected from the turbine or boiler control panel or (for such services as circulating water) from local control panels.

Auxiliary supplies for the whole station are arranged on the unit system, and are derived from 11·8/3·45kV, 6MVA unit transformers, one of which is connected to the terminals of each alternator. An alternative (standby) supply is taken from the two 132/3·45kV, 10MVA station transformers. It is estimated that the auxiliaries will use about 5·8 per cent of the energy generated by the completed station. All the auxiliary switchgear is single-busbar, air-insulated, solenoid-operated, truck-mounted equipment with a rating of 150MVA at 3·3kV and 25MVA at 415V ; the 3·3kV system is resistance earthed and the 415V system is solidly earthed.

Each alternator is connected, through an 11·8/141·6kV transformer, to the 132kV outdoor switchgear, the machines being switched and synchronised at that voltage. All the transformers are outdoor equipments fitted with conservators and installed in separate compounds, adjoining the switch house along the south-west wall of the station. A fixed system for fire detection and extinguishing is provided for the outdoor transformers, the turbo-alternator oil system and the induction regulators associated with the variable speed boiler auxiliary motors.

Control Room

All the controls that are essential to the operation of the 132kV switchgear, the synchronising and loading of the alternators and the main circuits of the auxiliary supply system are concentrated in the control room. The motors in the pump house are also remotely controlled from this room.

The generator control desk, which can be seen in Fig. 6, is divided, functionally, into three parts. In the central portion, immediately in front of the controller, are the loading instruction panel and communications equipment. The two wings of the desk carry the essential instruments (including MW/MVAR meters) and controls for the operation of the alternators. A cubicle type 132kV control panel with a mimic diagram is arranged in an arc in front of the control desk ; synchronising equipment is mounted on the end sections of these panels. At the other end of the room there is a similar control panel for the works auxiliary switchgear and the river water pump control desk. There is provision for two similar boards to be added along the remaining walls of the control room to deal with the " B " station.

Switchgear

The switching compound lies to the south-west of the main station building. The 132kV switching station consists of fifteen bays of air blast outdoor switchgear, with a rating of 3500MVA. The isolators associated with the busbar sections are motor operated ; the remaining isolators are manually operated. A typical 1200A triple-pole isolator is shown in Fig. 4. It is hydraulically operated by remote or local control, with provision for local manual operation, and is fitted with ice breaking contacts. Beyond the 132kV switchgear is the 275kV air blast switchgear, which has a rating of 7500MVA and will link the " A " and " B " Drakelow power stations with the Supergrid. A unit of this switchgear is shown in Fig. 3 during erection.

The construction of Drakelow " A " power station is being directed by the generation construction department of the Midlands Division, the Central Electricity Authority. The consulting civil engineers are L. G. Mouchel and Partners, Ltd. The main contractors are named in the accompanying list.

Civil engineering works and building superstructure Sir Robert McAlpine and Sons (Midlands), Ltd.; steelwork superstructure, coal bunkers, John Lysaght (Bristol Works), Ltd.; brick chimneys, P. C. Richardson and Co. (Middlesbro'), Ltd.; cooling towers, Mitchell Construction Company ; steam-raising units and ash-handling plant, International Combustion, Ltd.; turbo-alternators and generator transformers, The English Electric Company, Ltd.; station transformers, British Electric Transformer Company, Ltd.; condensing and feed heating plant, Worthington-Simpson, Ltd.; boiler feed pumps, G. and J. Weir, Ltd.; artesian wells, C. Isler and Co., Ltd.; coal-handling plant, Mitchell Engineering, Ltd.; circulating water pipework and h.p. steam and feed pipework, Aiton and Co., Ltd.; river water pumps, Drysdale and Co., Ltd.; river water pump motors, Laurence Scott and Electromotors, Ltd.; river water screens, F. W. Brackett and Co., Ltd.; water softening plant, John Thompson-Kennicott, Ltd.; fire protection installation, Mather and Platt, Ltd.; switchgear, 275kV, 132kV, 3·3kV and 415V, A. Reyrolle and Co., Ltd.; 415V motor control gear, Laurence Scott and Electromotors, Ltd., Contactor Switchgear, Ltd., and Brookhirst Switchgear, Ltd.; batteries, The Tudor Accumulator Company, Ltd.; electrostatic precipitators, Sturtevant Engineering Company, Ltd.

Steelworks Electric Overhead Travelling Cranes

No. II—(*Concluded from page 592, October 21st*)

A CONFERENCE on steelworks cranes, arranged by the British Iron and Steel Research Association, was held at Harrogate on October 5th and 6th. On the second day, the following paper was presented by Mr. C. E. H. Morris, in the unavoidable absence of the author:

SOME MECHANICAL MAINTENANCE TROUBLES ON LONG TRAVEL DRIVES

By I. S. SCOTT-MAXWELL (The Steel Company of Wales, Ltd.)

A wide variety of crane troubles occur in steelworks such as those of The Steel Company of Wales, where, at the Port Talbot, Margam, and Abbey works, there is a total of 160 E.O.T. cranes of various types ranging in capacity from 5 tons to 325 tons and from 22ft to 117ft span.

Long-Travel Driving Wheel Assemblies.—Four-wheel, 20-ton cranes with taper tread driving wheels are in use with a rail head width of 3½in and tread width of 7½in, giving ample side clearance for weaving and out-of-gauge track. No serious trouble with excessive flange wear has occurred and bearing lubrication by Armstrong oilers is satisfactory. The fitting of larger couplings has overcome troubles due to the shearing of coupling bolts. Axle breakages, due to "notch effect," where the taper from the journal to the coupling meets the smaller diameter, have necessitated the redesign of the axle. Analysis of the steels showed low carbon and high phosphorus contents resulting in cold shortness and reduced resistance to shock. Such failures show the need for closer attention to design details and the quality of raw materials supplied in equipment for the steel industry.

Wheel Flange Wear and Bogie Steering.—The 40/15-ton, eight-wheel cranes used in the hot mill slab yard since 1952 are admittedly light for their duty (60 tons capacity would be more appropriate), and high deflection under load of the main girder undoubtedly affects performance. Even so, wheel life for the first two years was thirty-five to seventy-five weeks, but during the last year only six to eight weeks for trailer wheels and ten to twelve weeks for driving wheels due to excessive flange wear. With the variations in track and gantry span, &c., the clearance on a 3½in rail head and 6in tread width is reduced to about ¼in, which is insufficient, showing that cranes should be designed to take full account of the track inaccuracies likely to occur in fast, hard-working cranes; ample rail/flange clearance must be provided. Both taper tread driving wheels are driven by cardan shafts from the same gearbox and wear develops in the fulcrum pin, particularly if there is flexibility in the bogie connection to the end carriage and between the end carriage and main girder connections causing bogie steering. The two taper tread drives try to revolve at different speeds, leading to gear failures; these have been eliminated by taking out the outer cardan shaft.

Parallel treads have now been fitted satisfactorily. On one crane a simplified gearbox for single-shaft drive has been fitted, additional bracings have also been fitted to the end carriage, and main and auxiliary girders for rigidity and the fulcrum pin brackets have been strengthened. This crane has since been running for ten weeks with considerably reduced load on the long travel motor and with the flanges hardly touching the rails. On some other similar cranes, pads have been fitted between the bogie frame and end carriage in an attempt to prevent steering of the bogies.

Ingot stripping cranes have heavier duties than slab yard cranes, but much less long travelling. Wheel life is sixty to 130 weeks with American type cranes which have virtually no end carriage, a narrow wheel base, one-ninth of the span, and the outside wheel of each pair of bogies driven. Driving wheels have taper treads and trailing wheels, parallel treads with side clearances of 4½in. Parallel tread driving wheels will be fitted in a new crane to the B.I.S.R.A. specification.

Three-hundred-ton casting bay cranes have two sets of bogies at each corner with a heavy equalising yoke, all attached to a cast steel bracket connected below the main girders. The inside wheel of each pair is driven. Wheels have parallel treads with a side clearance of 1½in, which will be increased as wheels are changed, since the gauge is up to 1½in narrow. Flange wear is heavy; on two cranes wheel life is eighteen months and on a third twenty-four to forty-eight months. Most of the wear is on the east side wheels, possibly because the variation of gauge is mainly on that side or the heavy surge load when cross travelling from the furnace eastwards to the teeming stands and braking over the moulds tends to keep the crane hard over on the east gantry. For heavy cranes with multiple bogies, gantry track alignment should be held more accurately than for lighter cranes with fewer wheels and the degree of steering with bogies should be reduced.

Drives.—The chief advantage of cardan shaft drives is that the gears can all be totally enclosed, allowing proper lubrication and a gantry free from oil and grease. No standards have been laid down as to which wheels should be driven and usually the layout of the driving shaft and gearbox is poor. Machining of gearbox sections should be sufficiently accurate for spare sections to be fitted easily.

Rails.—The method of rail fixing and type of expansion joint considerably affect flange wear. At the Abbey works, rails are welded to the gantry and long diagonal lap joints are used. Scale in the joints has caused expansion of a 3½in rail head to 5in at the joints.

Wheels.—Taper tread drivers will be used in future on four-wheel cranes, but not on bogie type cranes. Taper flanges will be fitted to give some protection against rail head wear, and side clearances between wheel flanges and rail head will be increased from ½in/1½in to 3in/4½in, where severe flange wear occurs. Higher tensile steel tyres are also being fitted.

A set of German rail head oiling rollers will be mounted on the end carriage to run against the corners of the rail head. W. S. Atkins and Partners have suggested that on bogie cranes V-tread wheels might solve the problem of wear; a special gantry rail with a replaceable top section may also be used. In Germany a four-wheel, 20-ton crane has been designed without flanges, but with side rollers bearing on an angle fitted to the top flange of the gantry. The crane is driven from both sides, but after starting the trailing motor cuts out. German cranes have larger diameter, but fewer wheels than British cranes; these seem to last longer and reduce flange and rail wear.

B.I.S.R.A. Specification.—An overall reduction in weight without reducing crane life will assist in long travel rail and wheel maintenance, but guidance on the number of wheels which should be driven, the optimum wheel base and the reduction of bogie steering would be helpful.

DISCUSSION

Considerable interest was expressed by the conference on the question of long-travel systems; it was felt that the main problems of crane-wheel wear were largely due to inaccuracies in the rail-track due to poor gantry building. A German delegate gave an interesting survey of wheel and track practice in that country. Studies have been made of many kinds of wheels and wheel profiles, and a strong body of opinion was developing that the best method, proposed by Dr. Hüser, who was present at the conference, was to do away with flanges altogether, thus eliminating all the problems which rose directly from flange wear, providing a system of side rolls to control oscillation. If flanged wheels are to be employed, the speaker agreed with a previous opinion that the tread width should be increased. He revealed that much smoother running had been achieved by fitting a 25 h.p. motor to drive each wheel, instead of one 100 h.p. motor. Adequate power, evenly distributed, was therefore available for overcoming initial inertia, and as the speed increased the trailing wheel motors could be cut after acceleration. Besides smoother running, the system provided a more positive control of acceleration.

Discussion revealed a general agreement that more attention should be given to the design of wheels. Every effort should be made to reduce axial float between wheel and axle, and speakers recommended wider treads, perhaps 3in to 4in greater than rail width. Rail lubrication might also be a possible solution. It was stated that a firm of consulting engineers was investigating the effect of various shapes of treads and axle systems. Scale models were being used to test various hypotheses, and a combination of both parallel and taper tread might prove to be the most suitable. From the discussion it appeared that some guidance on standardisation of tyre thickness would be useful.

The two following papers were next presented:

DEVELOPMENTS IN CRANE CONTROLS AND MOTOR DRIVES

By L. N. BRAMLEY (B.I.S.R.A.)

Crane Controls.—When the Steelworks Cranes Sub-Committee started writing the specification for E.O.T. cranes in 1946, it became apparent that crane cab layouts and controls were in urgent need of improvement. New cabs are now designed with adequate attention to details such as seating, visibility, type and arrangement of controllers and brake pedals, cleaning of windows, heating, ventilation, &c. A cheaper model of the ergonomically designed seat is being built. Controllers are now of the right shape, although they are still too large to allow the driver to leave the cab rapidly in an emergency. One firm, however, has overcome this difficulty by hinging the seat sideways. The design of smaller controllers is also in hand, but these may not be suitable for the long life required in a steelworks. The number of controller notches can also probably be reduced and an analysis is being made on production cranes in steelworks by recording on teleprinter tape the use made of each step. So far results confirm that the first and last notches are used more frequently than the intermediate notches. Elimination of notches will not affect smooth running, since the same number of resistance steps can be retained. A laboratory investigation of the optimum size of handle, number of stops, type of locator and arc of movement of the hand is also proceeding, together with experiments on the use of foot controls. Controllers with dimensionally variable controls are used by operators to control motors operating movable jockeys and all their actions are recorded on teleprinter tape. One steelworks claims that a crane with an efficient cab layout on the lines indicated by B.I.S.R.A. is capable of doing twice as much work as other cranes.

Motor Matching.—Considerable difficulties exist in choosing a motor for intermittently loaded drives such as those on cranes. Professor Tustin, now occupying the chair of electrical engineering at the Imperial College of Science and Technology, however, has suggested the "heating value" approach in which the size of the motor is based on measured temperature rises, rather than on rises calculated from a knowledge of the losses. It is essential to have some information on the duty cycles of cranes and work has been proceeding steadily to collect data on cranes over extended periods using perforated tape recording. Fortunately, in choosing a motor, its most onerous duty cycle is the main consideration. If a shop is being fully worked, the output will be a reasonable constant, which it will be difficult to exceed. "Behaviour Factors," the ratio of actual to theoretical movements, will be determined from the data collected and from calculations made knowing the minimum crane movements necessary and the shop layout. These factors will then be used in predicting the duty cycles for new cranes and hence, using the heating value curves, the sizes of motors required.

ELECTRICAL EQUIPMENT OF STEELWORKS CRANES

By R. A. WEST (Contactor Switchgear, Ltd.)

A.C. versus D.C.—Generally d.c. has been regarded as more suitable for electric overhead cranes, due to its overload capacity, freedom from voltage weakness and favourable speed and heating characteristics, although capital and running costs for a.c. may be cheaper per ton of material handled. The latter is only used to any extent for wharf cranes in this country, since they require fewer current collectors than steelworks cranes. Also the clearances allowed for d.c. cranes of less than 250V are such that the electrical equipment can be fitted conveniently into normal designs of crane. A reduction in clearances for a.c. cranes might be possible if a transformer were used to provide a safe low voltage for lighting, heating and control circuits, handled by the operators; this would encourage the use of a.c. and so reduce the cost of cranes.

Circuit Breakers, Switch Fuses and Crane Protective Panels.—Both fuse and overload protection are unnecessary on the same motor circuit, but the former is a nuisance after it has blown, whereas automatic resetting is provided with protective panels. Back-up protection, i.e. circuit breakers or fuses, is necessary, however, as the short circuit capacity is too great for the contactor of the protective panel. An emergency stop button which can disconnect the whole supply should be fitted for operation. An alternative means of stopping every motion, such as a circuit breaker with an emergency stop button to disconnect the whole supply, must be provided and on d.c. an auxiliary contact to disconnect the control circuits from the regenerated voltage of the hoisting motion when lowering a heavy load. If the circuit breaker is not near the driver, a push button is normally placed in the cabin and a no-volt release is fitted to the breaker. The latter, however, will trip on every interruption of supply; to save leaving the cabin and resetting the breaker by hand each time, the driver often puts the no-volt release out of action without thought to future safety. A shunt trip

device is, therefore, preferable for remote tripping, as this does not trip unnecessarily each time the supply fails. High pressure wiping contacts or metal contacts of 40 per cent Ag, 60 per cent Pd, should be used with not less than 200V. The emergency system should also be operated once every shift to ensure that it is working.

Wiring and Cables.—Some troubles have been reported with copper-sheathed mineral insulated conductors and it would be interesting to hear whether any of these are due to fatigue failures caused by the weaving of the crane structure. Plastic deformation occurs with P.V.C. cables at high temperatures and these are not, therefore, recommended in hot conditions. More use should be made of flexible tails between permanent wiring and equipment such as motors, brakes, controllers and contactor panels. Colour-coded wiring, an expensive item, is not recommended particularly as the lighting is not usually good enough to make full use of it.

Terminals.—Both numbered ferrules and terminals for internal wiring are unnecessary ; it is cheaper to number the terminal strips for harnesses, but for bunches of flexible cable, ferrules are better without numbers on the terminals.

Collectors.—Metal slippers are extensively used for long and cross travels of large cranes with high currents ; sintered contacts and carbon inserts are only used for smaller cranes.

Motor Converters and Rectifiers.—In a small steelworks, the adaptability of d.c. motors permits a reduction of spares, but in a larger works so many spares are carried that the choice between a.c. and d.c. can be made according to merit for the duty. One control gear manufacturer uses common parts for a.c. and d.c. contacts and operating mechanisms, except for magnets ; this reduces the numbers of spares.

Brakes.—Emergency brakes are fitted to back up service brakes ; two service brakes of three-quarters normal size would be cheaper, reduce the inertia and reduce the maintenance of shoe linings. Short-stroke direct acting d.c. solenoid operated brakes or a.c. electro-hydraulic brakes are now mainly used for service brakes ; these types unlike those on pre-war cranes, which were too small and of poor design, are reliable and efficient and the same need for emergency brakes no longer exists.

Control Gear.—Master Controllers : These should be reliable and easy to operate, requiring a light touch and the minimum hand movement with only two or at most three notches. New types should prove to be as long lived as the older heavier types, but they should be regarded as semi-expendable spares. Power-assisted master controllers might well be developed for use in steelworks ; the high cost of the servo-mechanism would be off-set by the saving in weight and cost of the contactor gear.

With a shunt wound brake, the number of contactors for a lowering hoist can be reduced from eleven to seven. With a series brake for plain reversing drives, excluding traction, two or three resistance contactors instead of four or five are sufficient.

A small amount of permanent rotor resistance will avoid passing over the hump of the speed-torque curve in slip-ring motor control, 20 per cent for motors of 250 per cent pull-out torque or 17 per cent for motors of 300 per cent pull-out torque (the resistance required varying inversely as the pull-out torque). Three motor contactors are sufficient for all a.c. drives except traction and for hoists the resistance can be reduced to 5 per cent. Weight and costs can be reduced by using line drum controllers, which are practically proof against too rapid manipulation. For the larger powers of a.c. motors, contactors are preferable.

Improved designs of a.c. contactors with either a slugged d.c. relay or a totally enclosed mechanical timer now give many years of reliable service ; replacement timers can be fitted in a few minutes when necessary.

Discussion

From the discussion on Dr. Bramley's and Mr. West's papers, it was apparent that much thought was being given to the question of the design of crane controls. Three-notch master controllers gave satisfactory service, and were quite adequate for all controls. There was general agreement that master controllers could be reduced in size—one speaker even suggested that they could be reduced to one-tenth. At the same time, handles could be similarly reduced, and designers might well think in terms of finger rather than hand operation. A desk type master switch fitted on the floor of the cab and driven by a joy-stick was another variation which was thought to have possibilities. Smaller dimensions also made it possible to consider using easily replaceable plug-in controllers.

Successive speakers agreed with the principle of installing the control units outside the cab of the crane, actuated by remote teleflex control ; this could possibly lead to the development of a cab in the form of a plastic " bubble " positioned away from the main structure and offering maximum visibility to the operator. Several speakers expressed concern over this question of visibility ; a 6in steel band at the foot of the cab could, in certain positions, obstruct the driver's view of the hook. The possibility of designing a standard cab could usefully be considered ; such a cab had, in fact, been adopted by one European firm.

It was generally agreed that there should be much closer co-operation between electrical and mechanical engineers in relation to control design and layout. The introduction of prewiring could materially reduce the time taken in erection. Speakers were in favour of numbering cables rather than colour-coding, as quite a number of people were, unknowingly, colour-blind.

On the subject of motor matching, one speaker advocated that in cases of motor overheating the solution was not always a larger motor ; an analysis of the duty cycle might mean that for normal duty a smaller size would be more suitable. The data which B.I.S.R.A. was obtaining on actual crane duty cycles would be most useful for long-travel drives where acceleration of heavy cranes was involved ; for hoist motions the standard method of choosing a motor was entirely satisfactory as all the horsepower developed was used in raising the load. The question of choice of gear ratios was most important.

The final paper of the conference was the following, presented by Mr. A. Entwistle (H.M. Engineering Inspectorate of Factories) in the absence of the author :

SAFETY CONSIDERATIONS IN THE DESIGN, OPERATION AND MAINTENANCE OF E.O.T. CRANES

By H. Eccles

Cranes are responsible for about 4000 accidents every year with 65 fatalities ; half of these occur with E.O.T. cranes, 200 at least of which could be prevented by taking the precautions in the design, installation and maintenance incorporated in the B.I.S.R.A. crane specification. It is to be hoped that those ordering cranes will make full use of this specification to ensure compliance with the law in respect of their cranes and equipment.

Limit switches should be of the direct acting positively operated type. Self re-setting switches can be dangerous as the operator may rely on the switch to bring the rising load to rest. Failures occur due to contacts becoming welded together by arcing across them with excessive use, and can result in the return sheave block being wound into the crab structure and the ropes breaking causing injuries to people below. A rising load can be halted independently by an automatic knock-off switch in the hoist control circuit, but this should always be in addition to a final limit switch. Spring release switches are also liable to contact sticking ; and limit switches operated by rotations of the hoist drum cause trouble if not re-adjusted after rope renewals, &c. These switches are also useless if a crane overlowers and, with the drum rotation unaltered, starts to rehoist.

Fencing requirements given in Section 17 of the Factories Act entail the casing in or guarding of every screw, bolt or key on any revolving shaft, spindle or wheel, and the casing in of all gearing, &c. In the past, the longitudinal travelling shaft spanning the bridge has caused serious accidents when situated above or within reach of the crane platform. Guards should be strong and arranged for quick removal and replacement to facilitate inspection. They sometimes get removed and not replaced because of the arduous task involved. Stout open mesh guards may be used to facilitate inspection without removal.

Access to crane cabins, bridges, tracks, &c., should be easy with suitable hand rails and toe guards.

Tracks should be level ; uneven tracks cause vibration and shock sufficient to loosen the track or other important parts and unbraked cranes have been known to run away. Tracks which are not parallel causing " crabbing " may result in the l.t. wheels leaving the track. Track supports must be of adequate strength to ensure the safety of the crane on the rails.

Braking facilities must be provided on all motions with adequate holding capacity, particularly in outdoor cranes subject to high winds.

Electrical equipment should comply with the electricity regulations, particularly in respect of guards for long and cross-travel wires.

Operation should always be by an experienced driver with a competent signaller and/or slinger, who should receive proper training and be fully aware of the capacity of all sizes and types of slings and the danger of swinging loads, &c. The driver must be comfortable in his cab with control levers conveniently placed as detailed in the specification and required by Section 6 of the Factories Act, 1948. Fumes should be kept away from the cab and in excessive heat conditions, heat resistant glass should be used.

Maintenance inspections at weekly intervals are essential, as well as the thorough examination required every fourteen months, and should include a check that all guards are in position and secure, in addition to the usual lubrication checks, and observation of any undue wear, &c.

The operator and those working on the crane must ensure against accidental operation of the crane. No workman should be alone on the bridge and adequate stops must be in place, if the cab is unoccupied, so that under no circumstances can the crane be set in motion without the consent of those working on the bridge. No other crane should approach within 20ft. Similarly, if anyone is working on the track, effective measures must be taken to ensure that no crane approaches within 20ft. The proper works safety drill should always be enforced at all times, particularly as contractors' men are often not so well aware of the routine in steelworks crane operation.

Discussion

The question of clearances for electrical equipment was particularly emphasised in the discussion, and adherence to the B.I.S.R.A. specification was considered essential. Several speakers emphasised that an efficient system of signalling between the operator and his slinger was essential, and that systems of carrier current communication should be developed. Industrial television might also have possibilities in this connection. On the general subject of accidents, the meeting agreed that most accidents were the result of carelessness. More prosecutions of individual offenders by the factory inspectors would have a salutary effect and lead to a reduction in accident figures.

* * *

Summing up the work of the conference, the chairman made two points. One was the necessity of specifying the load to be carried by the crane, and the other was the controversial subject of long-travel drives and the many different systems of wheel arrangements and profiles, bogies and track design which had been discussed. He felt that the crux of this particular problem lay in the design of the gantry ; with a good gantry orthodox designs would prove quite satisfactory.

Technical Reports

Methods of Determining Thermal Resistivity of Soil in Situ for the Calculation of Cable Ratings (Ref. F/T181). The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 15s., postage 4d.—This report describes three methods, the first being the hitherto accepted one employing buried spherical or cylindrical heaters ; this method is reliable but requires at least several days for each measurement. To satisfy the need for more rapid methods two have been worked upon and tested by the E.R.A. and are described in the report. One of these is the " transient needle " method in which a long, thin heater is placed in the ground and heated for about fifteen to twenty minutes, the thermal resistivity of the soil being calculated from temperature and time readings. The second rapid method involves the assessment of thermal resistivity from the soil constitution and moisture content as determined from samples suitably taken. It has so far been developed only for soils of clay, sand or a mixture of these. Both the rapid methods may be expected to give results agreeing with measurements by the sphere method within ±10 per cent except in certain extreme conditions.

Flameproof Electrical Apparatus. Flange-Gap Protection with a Fifth Series of Industrial Atmospheres (Ref. G/T292). By A. P. Paton, B.Sc., A.M.I.Mech.E., A.M.I.E.E. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 7s. 6d., postage 3d.—Figures for the maximum experimental safe gap and statistical maximum safe gap are given for flameproof enclosures with flanges ¼in in radial breadth with the following combustibles : acetone, normal butyl alcohol, ethyl ether, ethylene, ethylene oxide, heptane and methyl-ethyl ketone. The figures are compared with earlier results obtained with the same combustibles using a similar enclosure with flanges 1in in radial breadth, an improved method of determining the statistical maximum safe gap is also used and the results compared with those found by the original method.

Jet Flap

By I. M. DAVIDSON, B.Sc., A.F.R.Ae.S.*

No. I

At the Royal Institution on Thursday, October 20th, a paper to the Royal Aeronautical Society on the subject of the jet flap was presented and illustrated with a film. We print below abstracts from the paper.

THROUGHOUT the animal kingdom powered flight is a surprisingly common attribute and whenever it occurs the sustentation and the propulsion are both provided by the same structural and aerodynamic mechanism. There is, in fact, but a single aerodynamic reaction which is divided, for convenience, into thrust and lift. In earlier times this convention was presumably not recognised, for the ornithopter appears to have formed for some centuries the principal technical basis of man's aspiration to heavier-than-air flight. Of the exceptions, Leonardo da Vinci's helicopter is now, of course, an accepted vehicle, but this lecture is concerned mainly with fixed-wing aircraft for which it is significant that success came only with the aeroplane, or, as Lachmann[1] has recently put it, with the powered glider.

Given that development there grew apace the now classical theories of aerodynamics,[2] in the evolution of which it became apparent that the processes of nature could not only be emulated, but in certain directions surpassed. One such example is the study of boundary layer control, while another is the rise of engine aerodynamics ; and indeed these two disciplines now bid fair to usher in an era of what has aptly been described[3] as powered lift.

In that field two main trends could hitherto be seen. In one a small fraction of the engine working fluid is so used to control the aircraft boundary layer that the ultimate theoretical performance of an ideal wing can almost, but not quite, be realised. In the other there is the development of the lightweight gas turbine to a state from which its employment for the generation of pure jet lift seems only just around the corner. Thus, there is on the one hand a system in which the thrusting engine plays but a minor role and, in the other, one in which it is wielded as the *force majeure*. There is, in effect, a growing tendency towards the synthesis of the engine with its airframe ; but, so far, towards a synthesis which is essentially a design or technological achievement.

Whether such an integration is fundamental or artificial, aerodynamic or structural, may not at first seem important, for so long has the aeroplane now existed that its several unnatural vices are commonly taken for granted. Their magnitude may in some measure be recalled by thinking of the significance during the landing process of the stalling and minimum drag speeds. How many birds are commonly exposed, for example, to a landing hazard, and for what purposes do they employ the stall ?

In human and avian flight near the ground there are a great many differences, but of these only two appear vital—that the bird sports a complete mastery over the stall while, with its relatively low wing loading, it can fly much more slowly. In all species flight is naturally a means to an end and for that reason practical aviation is, and always will be, tied to wing loadings of about a hundred times those of the birds. Thus, for a bird-like performance to be possible, one obvious necessity is a means for the generation and control of very high lift coefficients—higher perhaps than anything which has previously been considered possible. The other is, naturally, the removal of the danger of the stall.

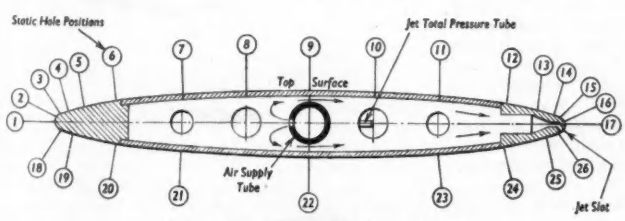


Fig. 1—Some details of the models

In recent years, a possible practical solution of just those difficulties has apparently emerged. This is the jet flap, which depends upon nothing more than the aerodynamic resynthesis of the lifting and propulsive means, the entire propulsive jet being ejected in the form of a thin, full span sheet from the trailing edge of the wing. Although novel, the underlying physical principle is by no means new, for it is commonly found as a side effect in experiments on boundary layer control by blowing over the top surface of a trailing edge flap. Indeed, in that guise it enjoys world wide recognition, the American term being supercirculation and the French, hypersustentation.

The first published information was that contained in a paper written by Hagedorn and Ruden[4] at Hanover in 1938. In France the discovery was made independently, the first trace being an unpublished paper written in 1942 by Valenci, Parigi and Borgel[5] at Marseilles. The first relevant French publication was by Poisson-Quinton[6] in 1948 while, as recently as December, 1954, Jousserandot[7] has described the results of extensive experiments in which the active principle was all but isolated.

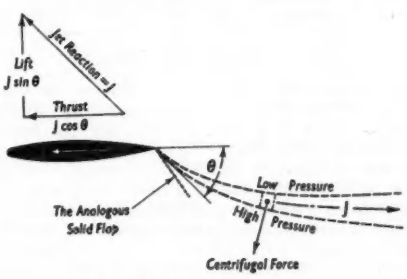


Fig. 2—The basic principle

In the U.S.A. the effect was demonstrated as early as 1931 by the early results of Bamber,[8] but there, as elsewhere, the emphasis was on the use of the jet for boundary layer control. The British trail is again a long one for, at the Royal Aircraft Establishment, the subject was broached by Lyon, Barnes and Adamson[9] in 1941, and again by Mettam[10] in 1951.

However, in all the early works the vital principle seems to have been considered mainly as a scientific curiosity, and the crucial step was not taken until November, 1952. That step was the observation by Constant that, the propulsive jet of a modern aircraft being a very powerful physical entity, it should be 100 per cent combined with the wing in flight near the ground.

PART I : THE LIFT ON A TWO-DIMENSIONAL WING

Basically, the gas stream from a jet flap acts just like a large Fowler flap. It baulks the lower mainstream, forces it over the wing and so, following Bernoulli, aerodynamic lift is generated. This argument is simple enough, but it implies that the jet path is already known ; that there is in fact a worthwhile downward penetration of the mainstream. Among other things, the effect must clearly depend upon the speed of the aircraft and the setting of throttles so that there is, as with the ornithopter, some inexorable combination of the lift and the thrust. To discover the laws of that combination it is best to consider the mechanism in two-dimensional flow.

The Demonstration Equipment.—In the first instance testing was restricted to a model (Fig. 1) in a 5in by 15in tunnel constructed of plywood, "Perspex" and paper, by the scientific staff. For obvious reasons, the results of those exercises are best forgotten, but they did serve a useful purpose in pointing the way. For example, a rapid series of tests in which the jet was composed of hydrogen and nitrogen in differing proportions showed at once that variations in the jet density and velocity were not of much consequence. All that seemed to matter was its thrust.

The Lift and Centre of Lift.—The basic aerodynamic mechanism is illustrated in Fig. 2, where it is essential to distinguish between the engine thrust or total jet reaction J, and the reaction thrust $J \cos \theta$, on the aerofoil. Since, with or without mixing, the jet must be turned to flow parallel to the flight path and since it carries everywhere a momentum flux equal to J, each of its elements must exert a centrifugal force as shown. In turn, this force is balanced by a difference of static pressure across the jet such that the total lift on its centre line is equal to $J \sin \theta$, the original downward momentum flux. In the theory use is made of the idea of an analogous structural flap, shown dotted in Fig. 3, and from the size which this can assume, it will be seen that very high lift coefficients must in principle be possible.

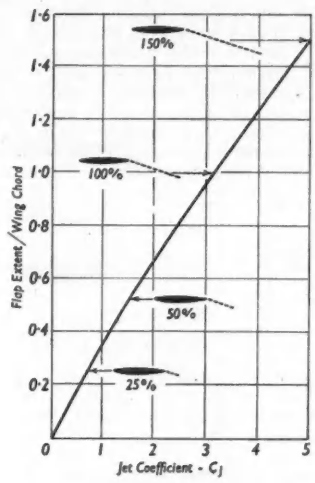


Fig. 3—The analogous flap size

In practice it is best not to divide the lift into an aerodynamic or pressure component and a jet or reaction component, but rather to think in terms of the whole. The results for the 58·1 deg. jet angle are quite typical, and Fig. 4 shows for that model the variation with C_J, the jet coefficient, of C_{L_0}, the total lift coefficient at zero incidence. From this diagram it will be seen that even the pressure or aerodynamic lift component is greater than could be generated by any other practical mechanism, while, besides the total, the idea of using only pure jet lift looks decidedly uneconomic. This last point is perhaps better illustrated by Fig. 5 in which the lift gain G is a direct measure of the total lift which can be generated per pound of available jet reaction. Thus, for many practical purposes the jet flap can be regarded simply as a jet lift

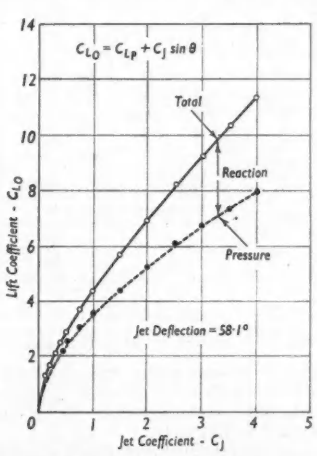


Fig. 4—Measured lift at zero incidence

* National Gas Turbine Establishment.

amplifier of which the gain lies generally between three and thirty.

In the present theory an empirical factor is involved in the estimation of the lift at zero incidence, so it would not be fair to attempt a comparison with experiment. The lift slope, on the other hand, is almost independent of that factor and so, in Fig. 6, a comparison is made between the measured values and the theoretical curve for an undeflected jet on a thin aerofoil.

For various reasons the conventional $C_M - C_L$ curve is not a good way of showing up the pitching behaviour of a jet flapped aerofoil, so in Fig. 7 an alternative presentation is adopted. In this diagram, which includes all the reaction effects, the total lift coefficient is plotted against the positions of the aerodynamic centre and the centre of total lift. Roughly speaking, the aerodynamic centre is at the quarter chord point and the centre of lift is at mid-chord, but for a given

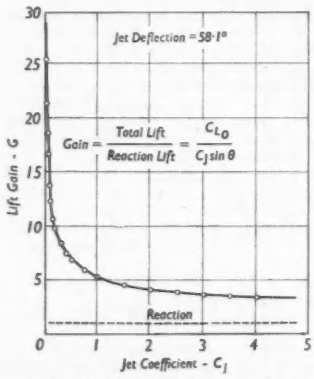


Fig. 5—Lift gain at zero incidence

thrust they both move gradually aft as the air speed is reduced. Fundamentally, of course, C_J and not C_L is the basic variable, and in Fig. 8 it will be seen that on this basis these two lift centres agree fairly well for all three jet angles.

Stalling Behaviour.—Whereas with a conventional aeroplane its incidence provides the one and only significant control derivative, $(\partial C_L)/(\partial\alpha)$, the lift on a jet flapped wing can be substantially altered at any incidence by changing either the jet angle θ or the jet coefficient C_J. Hence, in discussing stability it would seem necessary to consider all three derivatives—$(\partial C_L)/(\partial\alpha)$, $(\partial C_L)/(\partial\theta)$ and $(\partial C_L)/(\partial C_J)$. In practice, the situation is much simplified because, under high lift conditions, large variations in the

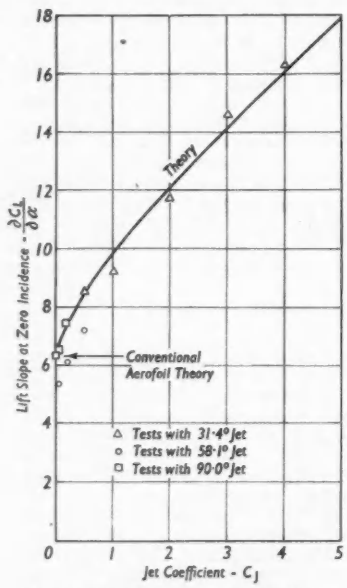

Theory
Conventional Aerofoil Theory
Tests with 31·4° Jet
Tests with 58·1° Jet
Tests with 90·0° Jet
Lift Slope at Zero Incidence - $\frac{\partial C_L}{\partial \alpha}$
Jet Coefficient - C_J

Fig. 6—Variation of lift with incidence

jet angle can produce rather unpleasant effects—certainly bad handling characteristics and possibly a catastrophic stall—so that $(\partial C_L)/(\partial\theta)$ can conveniently be forgotten.

The second simplification is that it is manifestly impossible to stall a jet flapped wing by increasing its thrust; C_L will go on increasing *ad infinitum* whatever the physical appearance of the flow. Not only C_L, but also all the other overall aerodynamic properties go on smoothly with C_J, despite what amounts latterly to a full-chord separation bubble. From Fig. 9 (a transcription of our photograph on page 374, September 9, 1955—Ed. The E.) the reason can be seen to be

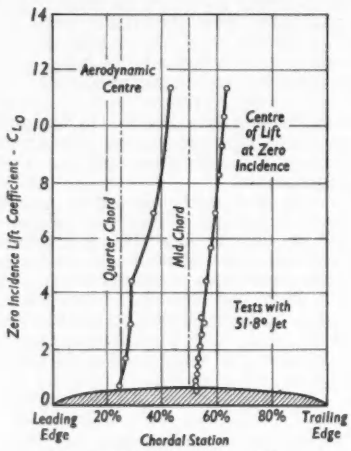


Fig. 7—The lift centre positions

the tremendous influence of the jet mixing entrainment effect. For example, from the undersurface flow it will be noticed that the main stream is actually turned to meet the jet, and the extensive nature of this inflow produces a rather interesting result. As the thrust is increased the stagnation point moves steadily aft, but at very high lift it eventually stops and then moves forward again.

That this entrainment process is also the key to the incidence stalling behaviour is suggested in Fig. 10, which depicts for the purposes of illustration a much simplified view of the real situation. In this view the entrainment effect is

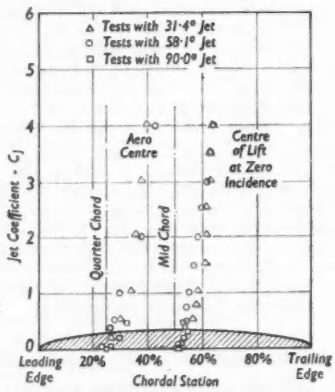


Fig. 8—Correlation with the jet coefficient

thought of as having a discrete sphere of influence. As the incidence is raised the separated mainstream is eventually thrown clear of this sphere, so that the bubble bursts to form an open wake; and this means a stall, that is, a reversal in the sign of the lift slope, $(\partial C_L)/(\partial\alpha)$. Naturally, the greater is C_J the bigger is the sphere of influence, and this space effect has two main results.

(i) As C_J is raised the danger of an incidence stall is reduced.

(ii) If two aerofoils be compared at the same zero incidence lift, but with differing jet angles, the one with the larger angle will naturally have the smaller C_J value and hence will be more prone to an incidence stall.

The experimental lift curves for the 31·4 deg. model are shown in Fig. 11, in which the stalling envelope appears to asymptote to the vertical at about +4 deg. incidence. Indeed, at a C_J value of 4·0 there is a suggestion of complete installability, but this should be treated with suspicion. In general, the lift curves do not curl over below +3 deg. and, when it does occur, the severity of the stall increases with C_J. The envelopes for all three models are shown in Fig. 12, from which it will be seen that, even with large jet angles, there exists in principle the possibility of producing an unstallable aircraft, for the lift can be raised indefinitely without crossing the envelope.

The full results for the 58·1 deg. model are shown in Fig. 13, where the lines will be seen to curve long before the stall. This is undoubtedly due in part to the greater volume of the separation bubble, but it is thought also to be connected with a substantial increase in the jet mixing losses—a point which is discussed later.

The Thrust of a Two-Dimensional Wing

Thrust and Drag.—Suppose for the moment that the jet fluid is not permitted to mix with the mainstream. Since the basic lifting mechanism is in no way affected by this change, the jet will continue to carry out of the system a horizontal momentum flux of J pounds. Hence, following Newton, the aerofoil must somehow or other experience an equal and opposite total thrust of J pounds, so that we have as a starting point the theorem that:

In an idealised two-dimensional jet flap system the gross thrust is equal to the total jet reaction

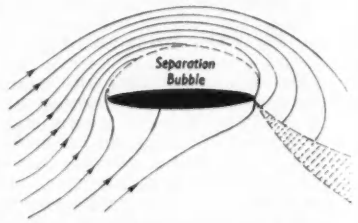


Fig. 9—Growth of the separation bubble

and independent of the angle of deflection of the jet.

There are several ways of looking at this situation, but they all lead to the same surprising result, which, while appearing all very neat in theory, seems far too good to have any practical meaning. But it has; for in quite crude experiments with obvious and appalling losses, a jet angle of 90 deg. and therefore no reaction thrust, can easily be persuaded to yield a pressure thrust of from 0·3 to 0·4J. One such example is that of Fig. 14, in which the proximate cause can be seen to be the substantial low-pressure region on the nose of the aerofoil.

Partly because it encourages one to strive for the last possible ounce of pressure thrust, but also for more prosaic reasons, the thrust of an aircraft is therefore taken to be the full value, J, of its engine thrust whatever the jet angle may be. Since the apparent losses are due to the jet mixing process, they can then fairly be described as jet drag and given, in coefficient form, the symbol C_{DJ}.

Again there are several ways of looking at the jet drag mechanism, but of these the simplest is perhaps that of Fig. 15, in which the aerofoil is at rest. In the entrainment process the surrounding air is accelerated locally in the vicinity of the

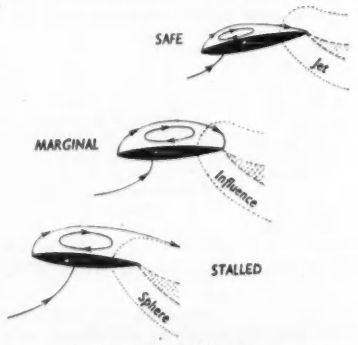


Fig. 10—The stalling process

trailing edge, so producing a suction drag on the profile. In flight there is, of course, a similar effect, but the rate of entrainment and hence the drag then depends upon the jet velocity relative to the mainstream; that is, it depends upon the rate of shear between the two fluids.

Some rough exploratory experiments were made with an undeflected jet issuing from a model, which aerofoil suffered on account of its

simple construction from a wandering transition point. Thus, under nominally identical test conditions, a number of quite different drag curves was obtained (see Fig. 16). The jet drag is given, of course, by the slope of these curves and, to make quite certain that there was no mistake, one test was made with a large leading edge spoiler fitted, as shown. The result is quite conclusive and it suggests that in cruising flight an aircraft with a cold propulsive jet must be expected to suffer from a jet drag which is equal

time. Nevertheless, by repeating the results under a number of slightly different conditions sufficient evidence was accumulated to show that there was undoubtedly a region of low thrust in which the jet drag was negative, as illustrated.

At Take-Off and Landing.—Now the magnitude of the jet drag has just been shown to depend upon the strength of the entrainment effect and so upon the shear velocity between the jet and the mainstream fluids. As this shear velocity

there is no direct evidence, but intuition suggests that a lift loss can be produced only by that mixing which occurs in the highly curved region of the jet before it turns parallel to the flight path. Thus even a large jet drag might correspond only to a moderate loss of lift and, in fact, this is borne out by the lift-incidence curves for the 58·1 deg. model.

If two given elements of the jet and mainstream are to be mixed with the minimum possible loss the process must clearly be conducted as gently as possible. To take one absurd but illuminating example : were the streams to be mixed entirely in a very low-pressure region of the field, the absolute velocities of both would

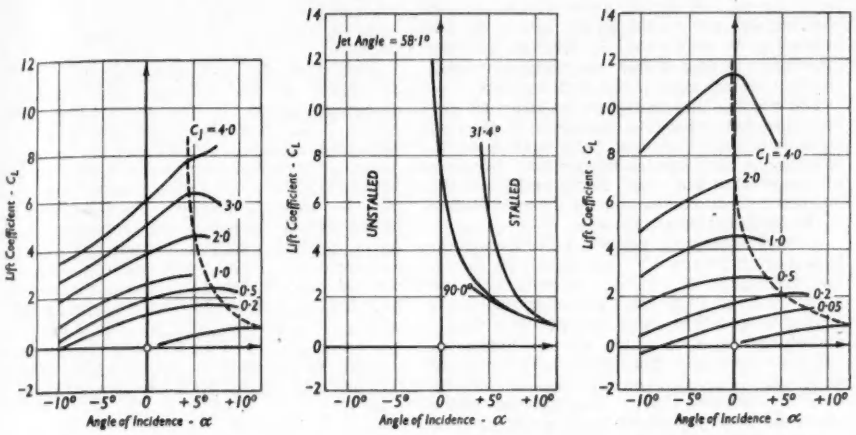


Fig. 11—Stalling behaviour of 31·4 deg. model

Fig. 12—The three stalling envelopes

Fig. 13—Stalling behaviour of 58·1 deg. model

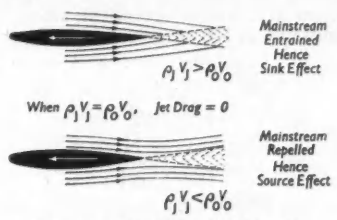

Mainstream Entrained Hence Sink Effect
$\rho_j V_j > \rho_0 V_0$
When $\rho_j V_j = \rho_0 V_0$, Jet Drag = 0
Mainstream Repelled Hence Source Effect
$\rho_j V_j < \rho_0 V_0$

Fig. 17—The effect of jet density

be high ; but, following Bernoulli, their mutual shear velocity would be negligible. Hence, the mixing could be effected without loss by a spoon travelling with the flow. This is merely another way of looking at the fact that the aerofoil, jet and mainstream can be considered respectively as the structure, primary and secondary fluids of an introverted thrust augmentor or ejector. Hence, by good design, the system can be made to yield in principle a thrust gain, so that the

in magnitude to some 5 or 6 per cent of the gross thrust.

Cruising Flight.—Since it is desirable in practice to use the same exhaust system at all times this last conclusion appears rather ominous, but fortunately there is one important variable which has yet to be taken into account—the density of the jet gas.

It has just been shown that when the jet and mainstream densities are the same there is, in practice, an entrainment or a sink effect, while in classical aerodynamics the growing boundary layer or wake of an aerofoil can be simulated by a source effect. Hence, in such a system, the existence of sinks or sources, of a pressure drag or a pressure thrust, seems to depend upon whether the jet or wake velocity is greater or smaller than that of the mainstream. In a penetrating and markedly heuristic analysis, Stratford[11] has shown that the real criterion is that of Fig. 17 ; that is,

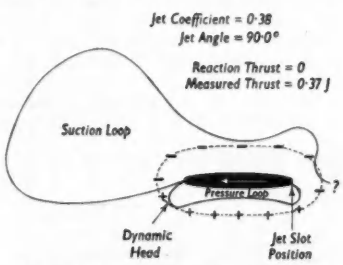


Fig. 14—The pressure induced thrust

that the significant variable is not the relationship of the two velocities, but is the ratio of the density-velocity product, $\rho_j V_j$, to that of the mainstream. When $\rho_j V_j > \rho_o V_o$ there is jet drag ; when it is smaller there is an analogous thrust and, as it happens, the value of $\rho_j V_j$ in cruising flight approximates closely to $\rho_o V_o$ for most practical aircraft, whether they be propelled by simple jet, by-pass or ducted fan engines.

In a confirmatory experiment the model was run with a pure hydrogen jet of which the thrust was progressively raised to give the result of Fig. 18. From the drag scale it will be seen that this experiment involved the measurement of very small differences, so on that account alone an accuracy of better than, say, ±10 per cent could not have been hoped for. On top of this difficulty the hydrogen was expanded from a reservoir at up to 3000 lb per square inch, so that, because of cooling effects, there could be no guarantee that the model slot width was invariant with

increases, so will the loss. Previously it was seen that with large C_J values the lower mainstream does not even run straight into the jet, but, near the nozzle, is turned to meet it head on. The violence of this initial mixing is thought to be one of the main sources of jet drag under high

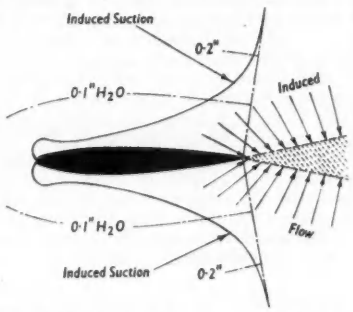


Fig. 15—The jet drag on an aerofoil at rest

lift conditions and is why C_{DJ} must be expected to increase rapidly with the jet deflection angle.

Since the jet drag must appear also as a loss of momentum flux in the mixed stream, there arises naturally the question of how this flux loss will affect the total lift on the system. On this point

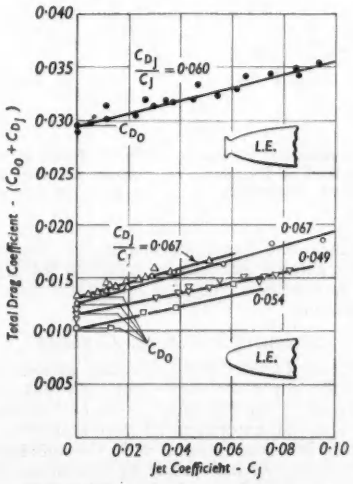


Fig. 16—The drag on an undeflected jet

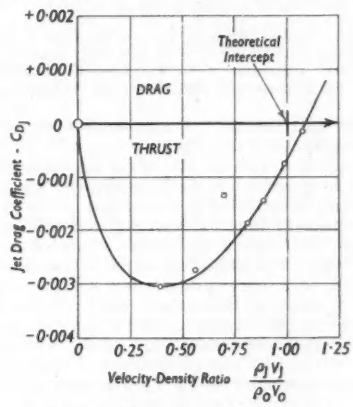


Fig. 18—The hydrogen test results

total thrust on the aerofoil is greater, not smaller, than *J*. Once more there are several ways of looking at the process and all of them give this same surprising result.

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(To be continued)

Metallurgical Topics

Effect of Tempering on Hardened 13 per cent Chromium Steel

WHEN an oil-hardened rustless steel is tempered there is a continuous and increasingly rapid fall in hardness with increase in tempering temperature above about 400 deg. Cent. The resistance to corrosion also falls, but it does so rather suddenly when the tempering temperature approaches 500 deg. to 550 deg. Cent., according to composition. With higher tempering temperatures, the steel recovers its resistance to corrosion at least to an appreciable extent. This is illustrated in Fig. 1, corrosion in 5 per cent nitric acid being at a maximum in the steel tempered at 525 deg. Cent.

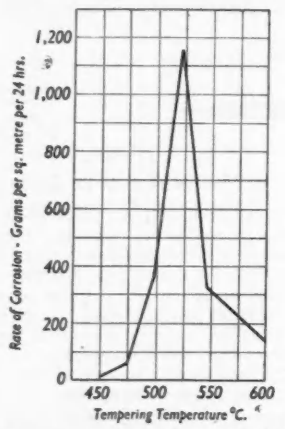

Fig. 1—Rate of corrosion in 5 per cent nitric acid of hardened and tempered 0·19 per cent carbon, 12·4 per cent chromium steel (Heiskanen). Change in mechanical properties also shown on different scales

This is a well-known effect and was commented upon by J. H. G. Monypenny,* who gave striking examples of the local loss of corrosion resistance of the blades of stainless steel table knives with brazed-on handles. This occurred, not where the tempering effect of the heat of brazing had been greatest, but a little further along where a temperature of about 550 deg. Cent. had been reached. Monypenny attributed the effect to the precipitation of chromium-rich carbides and offered alternative explanations of the phenomenon :—(1) The number of precipitated carbide particles is possibly greatest in steels tempered at 550 deg. Cent. or thereabouts ; their combined surface is at a maximum, so that the capacity for ordinary electro-chemical attack would be at a maximum. With the coalescence of particles at higher tempering temperatures it would be reduced. He points out that ordinary high-carbon steels are attacked by dilute acids faster after being tempered at 400 deg. Cent. than after being tempered either at higher or at lower temperatures. (2) Alternatively, he suggested that the fine particles which first separate consisted of nearly pure Cr_4C, with consequent impoverishment of the surrounding matrix in chromium and causing a fall in corrosion resistance. As it was well known that in the carbide of the fully tempered steel one-third of the chromium was replaced by iron, it would follow that during the balling-up process which accompanies tempering at the higher temperatures, the part of the chromium in the carbide replaced by iron would return to the matrix, improving its resistance. In the light of later knowledge, neither of these suggestions furnishes an adequate explanation of the phenomenon.

The effect of tempering on the structure and corrosion resistance of a hardened 13 per cent chromium steel has now been studied by S. Heiskanen† with special reference to the effect of temperature and time of tempering on the resistance to corrosion and on the constitution of the carbides that are formed.

A steel containing carbon 0·18, manganese 0·34 and chromium 12·7 per cent, with only a low percentage of residual elements, was oil-hardened from 1025 deg. Cent. after two hours at that temperature. The structure was wholly martensitic without any carbide, ferrite or retained austenite. Specimens were tempered at 25 deg. intervals from 425 deg. to 550 deg. Cent. for different times. They were tested for corrosion in a 5 per cent aqueous solution of nitric acid, their hardness was measured and a detailed study was made of the carbides present, including their isolation, micro-analysis, and examination by X-ray diffraction and electron microscope methods. Curves are given in the paper representing the changes, in hardness, corrosion resistance and composition of the carbides, which occur in the course of prolonged tempering at each of the temperatures studied. Those reproduced in Figs. 2 and 3 are typical. The rate of corrosion reached a maximum and began to fall again in specimens tempered at each of the temperatures provided that the tempering was sufficiently prolonged. The maximum rate of corrosion occurred in specimens :—Tempered at 550 deg., 525 deg., 500 deg., 475 deg., 450 deg. Cent., after tempering for half an hour, two hours, eight hours, fifty hours, 350 hours.

Study of the composition and constitution of the carbides isolated from the different specimens showed that the suggestion that the chromium-rich carbide Cr_4C (now more accurately known as $Cr_{23}C_6$) was first precipitated was not correct. The carbide at no stage gets poorer in chromium. On the other hand, the amount of chromium in the carbide increases progressively the higher the temperature and the longer the time of tempering.

Constitution of the Carbides

During tempering the carbides appeared in the following order :—$(FeCr)_3C$, $(CrFe)_7C_3$ and $(CrFe)_{23}C_6$. In the early stages of tempering, the ratio of chromium to iron atoms in the carbide is about the same as in the untempered martensite. As the carbide transformation proceeds with continued tempering, the chromium content of the carbides increases to about 75 per cent. The carbide $(CrFe)_7C_3$ is formed from the previously formed chromiferous cementite and similarly $(CrFe)_{23}C_6$ from the $(CrFe)_7C_3$ and not by direct precipitation from the ferrite matrix. This may explain the non-appearance, during the tempering of chromium steels, of any marked secondary hardening such as is known to occur in steels containing vanadium, molybdenum or tungsten.

Simultaneously with the concentration of chromium in the carbides, a reduction of chromium occurs in the surrounding ferrite matrix. The low chromium cementite is in metastable equilibrium with a very low chromium ferrite (about 0·6 per cent) at the contact surface, but the low chromium regions round the carbide particles are very narrow. As the chromium in the carbide increases, the chromium in the ferrite in contact with the carbide also increases and the ferrite regions with reduced chromium content become broader. When the carbides have reached their equilibrium chromium content (about 75 per cent at 550 deg. Cent.) the chromium content of the ferrite at the surface of contact has increased to its corresponding equilibrium value (about 10·5 per cent at 550 deg. Cent.).

Influence of Carbide Formation on Corrosion

The corrosion resistance of the 13 per cent chromium steel is high in the hardened and untempered condition. The occurrence of a condition giving maximum corrosion is explained by Heiskanen on the following lines. On tempering, a great number of local cells are formed as a result of the difference in chromium content at the carbide/ferrite surfaces and the rest of the ferrite. In contact with an electrolyte (e.g. during corrosion testing) the low-chromium ferrite regions function as anodes, and the high-chromium ferrite regions (and carbides) as cathodes. In the early stages of tempering there are great differences in chromium content and, therefore, in potential between the anodic and cathodic regions, but since the anodic regions are very narrow the average corrosion of the whole test area is relatively low. At a certain stage of tempering the potential differences and the magnitude of the anodic surfaces co-operate in such a way that a very high corrosion rate results. After a long tempering the potential difference has become so small that the local cells cease to function and the corrosion resistance of the material becomes relatively high again.

Both the drastic corrosion and the recovery of corrosion resistance occur at the stage when the carbide $(CrFe)_7C_3$ is present. The effect is largely governed by the diffusion of chromium into the low-chromium regions, and it is therefore or interest to note that it was possible to calculate the activation energy of the process which causes maximum corrosion, and that its value was found to correspond rather well with the activation energy of chromium diffusion in ferrite.

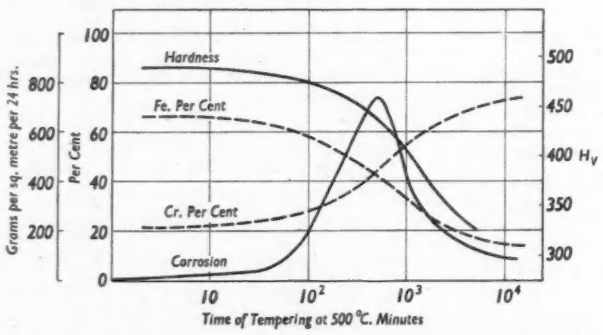

Fig. 2—Effect of time of tempering on the hardness, composition of the carbide and rate of corrosion in 5 per cent nitric acid of oil-hardened 12·7 per cent chromium steel tempered at 500 deg. Cent. (Heiskanen)

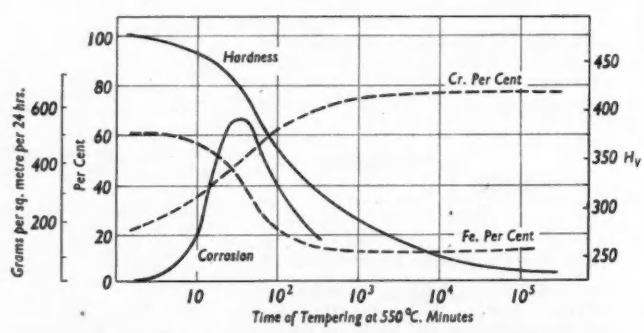

Fig. 3—Effect of time of tempering on the hardness, composition of the carbide and rate of corrosion in 5 per cent nitric acid of oil-hardened 12·7 per cent chromium steel tempered at 550 deg. Cent (Heiskanen)

* *Stainless Iron and Steel*, Vol. 1, page 244.

† *Jernkontorets Annaler*, 1955, No. 6, page 311.

Low-Expansion Alloys

THE first alloy having a very low value of thermal coefficient of expansion over a limited range of temperature was Guillaume's 36 per cent nickel-iron alloy, generally known as "Invar," but produced by other manufacturers under different names. The addition of all elements, with the exception of cobalt, appears to increase the minimum coefficient of expansion attainable. Nickel-iron-cobalt alloys have, however, been developed with a coefficient of $0{\cdot}5\times10^{-6}$ per deg. Cent. at room temperature and are manufactured under the names of "Superinvar" and "Super-Nilvar." Moreover, by varying the nickel and cobalt contents, the coefficient may be varied to meet different requirements, such as glass-to-metal seals which need a metal having a

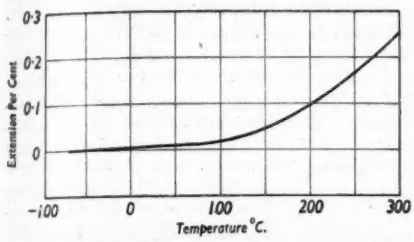

Fig. 1—Extension per cent of cobalt-iron-chromium alloy No. 1781 (Table I) from −65 deg. to 300 deg. Cent. Total extension, −65 deg. to −20 deg. Cent., 0·008 per cent.

moderately low coefficient of expansion of the order 5×10^{-6} per deg. Cent. Suitable glass-to-metal seals can also be made without the use of cobalt but by the addition of up to about 6 per cent of chromium to the nickel-iron alloy whose coefficient is thereby increased by the necessary amount.

It has been known for some time that cobalt may play a similar part to nickel in the development of low-expansion alloys. In 1934, H. Masumoto* reported very low coefficients of expansion in some cobalt-iron-chromium alloys. For example, an alloy of the nominal composition cobalt 56, iron 34·5 and chromium 9·5 per cent had a coefficient of expansion of $0{\cdot}1\times10^{-6}$ per deg. Cent. between 20 and 60 deg. Cent. Similar alloys with a constant value of Young's modulus were described under the name of Cobalt-Elinvar, by H. Masumoto and H. Saito† in 1949.

A thorough examination of the claims for these alloys has been undertaken by P. Hidnert and R. K. Kirby.‡ Effects due to variation of composition and heat treatment have been determined. The alloys were made in a high-frequency induction furnace, a master alloy of cobalt and chromium being first prepared, and were deoxidised with a calcium-silicon alloy. They contained about 0·07 per cent each of carbon and manganese and up to 0·3 per cent

TABLE I—*Examples of Low-Expansion Alloys*

	1773	1783	1781 (Fig. 1)
Composition per cent :			
Cobalt	53·92	54·09	54·21
Iron	36·22	36·61	36·56
Chromium	9·67	9·15	9·06
Average Coefficient of expansion Parts per million per deg. Cent.			
−60 to −20 deg.	0·3	0·35	−0·8
−20 to +20 deg.	1·2	−0·25	−0·4
−60 to +20 deg.	0·75	0·05	−0·6
20 to 60 deg.	3·6	1·0	0·8
60 to 100 deg.	6·8	2·7	2·5
100 to 150 deg.	11·2	6·3	5·6
150 to 200 deg.	14·4	11·9	10·0

of silicon. Many of the alloys showed the $\gamma\rightarrow\alpha$ transformation on cooling to a low temperature, in some cases no lower than −10 deg. Cent. This transformation is of the martensitic type, producing an acicular structure in the alloy, a rapid increase in length and a slight evolution of heat. Only the γ solid solution showed low expansion properties. The coefficient of expansion increased with increasing amounts of the α phase, but the γ condition was restored in a specimen containing α by heating it to about 600 deg. Cent. and allowing it to cool. The low coefficient of expansion generally applied to the temperature range −65 to +60 deg. Cent. only, the minimum values to an even shorter range. Some typical results are given in Table I and the results on one alloy illustrated in Fig. 1.

The $\gamma\rightarrow\alpha$ transformation occurred at −80 deg. Cent. in alloy 1783.

While the average coefficient for the alloy shown in Fig. 1 was less than 1×10^{-6} over the range −65 to +60 deg. Cent., it rose rapidly to 15×10^{-6} over the range 200 to 300 deg. Cent. Similar increases are shown by the other two examples in Table I.

The conclusion was reached that annealed alloys having chemical compositions about cobalt 54, iron 36·7 and chromium 8·9 per cent have thermal coefficients of expansion less than 1×10^{-6} per deg. Cent. for the range 20 to 60 deg. Cent. Their behaviour over this restricted range is rather better than that of ordinary "Invar"; but close control of chemical composition is a prerequisite to success in the production of low-expansion cobalt-iron-chromium alloys.

Failure of Gear Teeth

IT is well known that the original dendritic pattern of an ingot will survive a considerable amount of hot working. Thus, an etched section of a round bar, rolled from a square ingot, may clearly show the pattern of the original ingot, the position of the corners being particularly evident. Non-metallic inclusions are liable to be trapped on the diagonals at the corners of the ingot, and these when drawn out into an elongated form during rolling are liable to affect the properties of the steel at these positions.

An interesting example of the persistence of the influence of ingot structure has been described

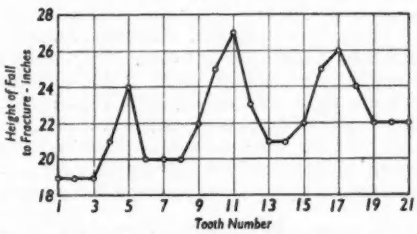

Fig. 1—"Impact Strength" of successive gear teeth in a bar stock gear (Kauper)

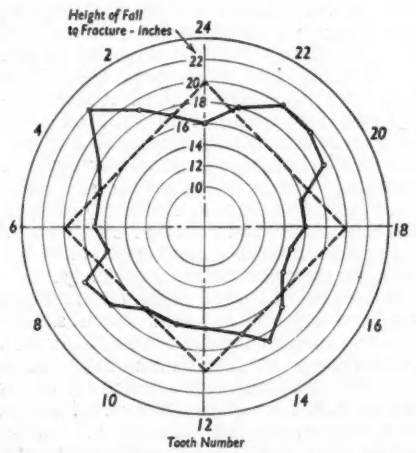

Fig. 2—"Impact Strength" of successive teeth in relation to the square ingot pattern—average of four gears (Kauper)

by A. J. Kauper in a paper on "Impact Failure of Gear Teeth."* He had encountered instances in which gear teeth were breaking after extremely short periods of service. In the course of the investigation of these failures he observed that the damaged teeth occurred at similar positions relative to the macro-structure which revealed the position of the corners of the original ingot. He designed a drop weight impact machine in which the energy of the falling weight was applied to individual teeth of the gear. The weight was dropped from a height known not to cause fracture; then the height of fall was increased 1in or so at a time until fracture occurred. The final height from which the weight was dropped was taken as a measure of "impact strength." With this apparatus an experiment was carried out on a number of specially made gears to ascertain whether the ingot pattern affected the tendency to failure under impact. The steel was the same as that of the gears which had failed, viz. carbon 0·17, chromium 0·5, nickel 0·6 molybdenum 0·2 per cent approximately. The surface was carburised to a depth of 0·03in. The

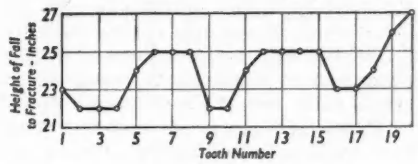

Fig. 3—"Impact Strength" of successive teeth in a forged gear (Kauper)

hardness of the surface of the gear teeth was 59–62, and that of the core 30–40 Rockwell "C."

The gears were made from a bar of this steel, rolled from a square ingot, and macro-etching of sections of the bar showed an ingot pattern. There was no rotation of the pattern from end to end of the bar. The "impact strength," measured by the minimum height of fall to cause fracture, was low near the corners of the ingot pattern, and high near the centre of the flat sides of the ingot pattern with an intermediate transition from low to high and vice versa. The plotted curve of "impact strength" (i.e. minimum height of fall to break) of successive teeth thus tends to resemble a sine curve with regularly spaced maxima and minima (Fig. 1). The relationship of these positions to the macro-structure is shown in Fig. 2 in which the inscribed square represents the orientation (but not the relative size) of the ingot pattern revealed by etching. The steel at positions corresponding to the corners of the original ingot showed minimum resistance to fracture by impact stresses.

This effect is dependent not only on how pronounced the dendritic structure of the original ingot was but also on the amount and distribution of the non-metallic inclusions which it contained. As the impact stress is applied transversely, the minimum figure will also depend on the amount of reduction the bar received on rolling. Gears made from a forged bar of the same steel showed a smaller variation in the height of fall required to produce fracture (Fig. 3) and the minimum figure may then be such as to ensure that no failures occur.

Metals Reference Book. Second edition. Edited by Colin J. Smithells. London: Butterworths Scientific Publications, 88, Kingsway, W.C.2. Two volumes. Price £8 8s.—During the past five years or so, the *Metals Reference Book* has proved to be of great value to metallurgists as a trustworthy source of quantitative information on a variety of aspects of metallurgical science and practice. The second edition, enlarged by about one-third, now appears in two volumes at an enhanced price. Apart from the correction of a few printer's errors and the substitution of recently determined and more accurate values in some of the tables, additions have been made to many of the sections including those on atomic nuclei and on equilibrium diagrams. The excellent monograph on Metallography which was one of the outstanding features of the first edition, has been extended, and descriptions of the technique applicable to some of the rarer metals, such as beryllium, titanium and zirconium, which have recently become important, have been included. New sections have been written on elastic properties and damping capacity, lubrication and friction. The section on lubrication contains a glossary of terms and much information on the selection of lubricants for various purposes, while the section on friction is a really valuable monograph on the subject. In its new form, the *Metals Reference Book* will continue to be an indispensable addition to the libraries of all metallurgical organisations.

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* Science Reports, Tôhoku University, 1934, Vol. 23, page 265.

† *Ibid.*, 1949, Vol. A1, page 17.

‡ *Journal of Research*, U.S. National Bureau of Standards, July, 1955, Vol. 55, page 29.

* *Metal Progress*, August 1955, page 73.

LETTERS AND LITERATURE

Letter to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

PRESERVATION OF STEAM ROAD VEHICLES

SIR—As a result of the growing interest in steam road locomotion, a public meeting was held recently at Redruth in Cornwall, the town in which the first steam locomotive was made by William Murdock in 1784. At the meeting it was resolved to form the "West of England Steam Engine Society," whose primary object will be to organise an annual public rally in some part of Cornwall or Devon, at which steam traction engines, steam rollers, steam cars and other old vehicles can be exhibited and seen in motion.

From the amount of support already received it is apparent that there is widespread public interest in such a venture. Its success or failure, however, will largely depend on whether a sufficient number of old road vehicles, and especially steam ones, can be brought together for display at these rallies. Several members of the new society are enthusiastic owners of traction engines and others would gladly renovate an old engine and provide a good and permanent home for it if they knew where one could be obtained. Unfortunately, scrapping of these grand old veterans has been taking place at an ever increasing rate in recent years and now only a few are left. I am therefore wondering if any of your readers know of a steam road vehicle of any type that could be renovated and preserved by our members. There must be several such lying about in out-of-the-way parts of Cornwall and Devon, and if the location and name and address of the owner of these could be sent to me I should be most grateful and would pass the information on to those of our members who are wanting to preserve such engines.

J. H. TROUNSON,
Chairman, West of England Steam Engine Society.

"Laguna," Redruth, Cornwall,
October 20th.

Literature

The Maintenance and Management of Small Locomotives. By H. E. WHITE, B.Sc. (Lond.). London: Percival Marshall and Co., Ltd., 19–20, Noel Street, W.1. Price 12s. 6d.

THE construction of working models of steam locomotives is a pastime that has become increasingly popular during recent years, and judging by the numbers of exhibits on view at the Model Engineer Exhibition year by year, it is very evident that much time and considerable ingenuity is expended on the production of these steam locomotives in miniature. The aim and object of this book is, to quote its author, "to outline the problems which face the model engineer, whose interest lies in the maintenance and running of small passenger-carrying model railways." While this is the main object of writing this little book, in actual fact the twelve chapters which it contains embrace many other subjects relating to the actual making of these scale models and also to the construction of the model railway tracks and the passenger-carrying trucks. This makes interesting reading if for no other reason than that it is distinctly novel, while it is also informative inasmuch as it brings to light certain aspects of this hobby which are a little surprising. For instance, it will be news to many to learn that there is in existence a parent body of the many model engineering societies in the country—the Society of Model and Experimental Engineers Affiliation, which has inaugurated and set in motion a scheme for the examination of drivers who aspire to drive one of the little engines when hauling a passenger train. Would-be drivers are given practical tests on the driving and management of the engine and, if considered proficient, are granted a certificate on payment of a small fee. This certificate gives permission to handle a small working model steam locomotive running on a railway of a certain specified gauge.

The model locomotives with which this book is mostly concerned are of relatively small dimensions when compared with miniature public undertakings such as the Romney, Hythe and Dymchurch 15in gauge line, the Ravenglass and Eskdale line in Cumberland, also a 15in gauge railway, and the somewhat larger 22½in gauge line, the Welsh Highlands railways in North Wales. The gauges chiefly mentioned by the author extend from a maximum of 10in to the smallest, which is 3½in. Intermediate sizes seem to be 5in and 7½in; the former is said to be the more popular. Locomotives built for this gauge are, however, fairly heavy, weighing upwards of 500 lb in some cases, while a minimum weight for a model of a small type of engine would, it is stated, be some 200 lb. Such models are therefore too heavy to manhandle readily and are for this reason usually confined to one railway track only.

Generally, model railway tracks of any considerable size are the property of clubs, one of which is the North London Society of Model Engineers. This is a multigauge line, thus being suitable for engines and trains built to different scales and gauges. In the early part of the book attention is given to the construction of model coal-burning locomotives, which is generally well explained with the necessary illustrations, either drawings or reproduced photographs. Working models, though often resembling the "real thing," are in detail very different in their construction from the locomotives on full-sized railways. As a case in point, consider the boiler where a model may have a short length of copper piping for the barrel section—very different and much simpler than this part of the real locomotive boiler! Then again, in the case of the model, practices are allowed which would not find favour for the actual full-sized locomotive; for instance, the diagram drawing showing the driving wheel boss and the axle with wheel seat shows the latter of less diameter than the body of the axle, a design that would certainly be frowned upon in actual practice. On the other hand, if found safe in model engineering, it assuredly offers a ready means of obtaining the correct lateral spacing of the wheels to suit the required gauge clearance. Pressing the wheels on axles between the jaws of a bench vice would come as something of a shock to the wheel shop foreman!

Considering crank axles and the correct setting of crankpins in their relative positions, the author is fully alive to the fact that this is of importance and shows a suitable jig used for the "quartering" of driving wheels. On the subject of three-cylinder engines, it is stated that the crankpins are placed at angles of 120 deg. to each other. This is correct so long as the cylinder longitudinal centre lines are in the same plane, but is not so, if, as often happens, the middle cylinder—that is, the one between the frames—is inclined relatively to the outside pair. In such a case, the inside crankpin centre is set back by an amount equal to the angular difference between the axis of the outside cylinders and the single inside cylinder. Discussing further the three-cylinder engine, the author states that having the three cylinders arranged in the same horizontal plane and in line transversely, all the cylinder blocks being the same distance from the leading coupled axle, has many advantages, and goes on to say that this system "must, of course, use the divided drive." This is by no means clear. Usually with this arrangement the drive is taken by the leading coupled axle when the "inside" cylinder drives through a single-throw crank axle and the outer pair through crankpins in the wheel centres. However, in the case of a model, the divided drive may be preferred. A hard and fast opinion will not be expressed on the particular point.

The chapter devoted to valve operating gears is, on the whole, well prepared. It deals effectively with Stephenson's link motion, Walschaerts and the Baker gears, all of which, it is learned, find more or less favour with model engineers. Regarding Walschaerts gear, there is a rather unlooked-for error where the following statement is made: "The distances between the three holes on the combination lever are so proportioned that the movement of the main crosshead at the lower end of the lever is reduced at the upper end until it equals twice the valve-travel-plus-lead, the wrist pin of the valve rod being the fulcrum." This is a slip on the part of the author, who clearly understands from the succeeding sentences that this movement is equal to the valve "lap" plus the "lead." During one complete revolution of the driving wheels, the motion imparted to the valve by the combination lever is equal to twice the steam "lap" of the valve plus the "lead" opening. The valve travel, as such, is controlled only by the angular swing of the expansion link actuated by the return crank through the connecting-rod.

Concerning the action of the blast pipe, it should be clearly understood that the draughting action of the exhaust steam sets up an "induced" draught. This is not "forced" draught as generally understood, and the motor-driven fan arrangement, described as being fitted to the top of the chimney and used for urging the fire after being first lighted, is not really a blower; it is used as an exhauster and, as such, sets up an induced draught through the ashpan and firebed on the grate. The tender is an important accessory to the engine; it carries a supply of coal and water and provides in most cases a seat for the driver. Feed water is often fed to the boiler by means of a single-acting plunger pump driven by an eccentric mounted on one of the coupled axles, and an injector is also fitted. The pump is fitted with a by-pass, the arrangement being such

that, when the locomotive is running, water is being circulated through the pump and returned to the tender tank, and the amount of feed delivered to the boiler is controlled by closing, or partially closing, a valve in the by-pass piping—a very simple arrangement.

The concluding chapters are largely given up to descriptions of the permanent way adopted for the operating of these small locomotives and their trains. This is well described and should be of interest and value to model owners.

In fact, the subject matter of this book is, in general, carefully written and the information given is of a distinctly practical nature, evidently compiled by a writer experienced in the building and running of these little locomotives.

Abhandlungen des Deutschen Kältetechnischen Vereins, Nos. 9 and 10. Karlsruhe: Verlag C. F. Müller. Price DM.5·50 each. — The *Abhandlungen* contains technical-scientific papers which exceed in length the space available in the journal *Kältetechnik*. No 9 consists of a paper entitled "Das Verhalten von Mineralöl"—F12—Gemischen in Kältemaschinen" (mineral oil from mixtures in refrigerating systems), by Dr.-Ing. G. Bambach. The author reports on a series of experiments carried out to ascertain the effects of lubricant admixture upon the thermodynamic properties of freon, and the influence of freon upon the viscosity of the lubricant. In No. 10 are to be found two papers, the first one dealing with the flow of boiling liquids through orifices, and the second, with flow through tubular restrictors. In "Untersuchung des Ausstrômvorganges siedender Flüssigkeiten," by Dr.-Ing. A. Förster, two approaches are compared, one assuming that no evaporation takes place during discharge, the other that adiabatic expansion occurs. Experiments with water show that the flow is many times that calculated for discharge with evaporation and approaching the figure for discharge without evaporation. With carbon dioxide the position is reversed, but even in the neighbourhood of the critical point the flow is found to be greater than the theoretical figure with evaporation. By means of non-dimensional quantities the results obtained under numerous experimental conditions are collated, and the introduction of reduced quantities enables an empirical calculation to be made of the flow of boiling water and boiling carbon dioxide up to the highest pressures. The second paper, "Der Durchfluss siedender Flüssigkeiten durch Drosselrohre und Mündungen," by Dr.-Ing. O. Linne, gives a method for the calculation of flow in tubular restrictors, taking into account the flow resistance of the liquid as well as the gaseous phase, and also the inertia forces. Nozzles and orifices are also briefly dealt with, by giving the mass flow as a function, not of the pressure as with gases and vapours, but of the saturation temperature at each pressure. Tabulated experimental results supplement the theory.

Electric Power Stations, Vol. II. By T. H. Carr, M.I.C.E., M.I.Mech.E., M.I.E.E., M.I.F. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 80s.—The fourth edition of this comprehensive book has been revised and enlarged but, such is the speed of progress in power station practice, that it is becoming increasingly difficult to encompass the subject even in two sizeable volumes. The second volume, which is reviewed here, devotes 832 pages to (*inter alia*) condensing, feed heating and water treatment, alternators, transformers and reactors, switchgear, cables, electrical protection, auxiliaries, lubrication, administration, commissioning and testing, hydro-electric and gas turbine plants and other methods of generation. The treatment of the newer prime movers, including atomic power plants, is compressed into the final fourteen-page chapter. If the present speed of progress in reactor design and construction may be taken as a guide, it is clear that the author will face a formidable task in ensuring that future editions of this volume shall be as up-to-date as their predecessors.

Institution of Naval Architects

AUTUMN MEETING

No. III—(*Concluded from page 590, October 21st*)

MR. R. B. Shepheard presided over the final session of the autumn meeting, in Yugoslavia, of the Institution of Naval Architects, which was held on Wednesday afternoon, September 21st. The following paper was read:—

DESIGN OF ECONOMIC TRAMP SHIPS

By E. C. B. Corlett, M.A., Ph.D.

The paper briefly outlines some of the background of development of the modern tramp ship and illustrates its emergence. Desirable economic and technical characteristics are analysed and items such as deadweight displacement ratio, cubic capacity, structural arrangements, lines, equipment and machinery are examined and their influence discussed. Suggestions are put forward regarding items of design which would be of advantage in tramp ships. The final section of the paper is concerned with suggested designs for a coaster, short sea trader, and two for an 11,000-ton deadweight tramp ship, one slow and the other fast, all of which are intended for engaging economically in tramping work.

Discussion

Professor Ir. S. Silovic: All of us will agree that turn round in port is as important as speed at sea, and that from the economical standpoint it does not make sense to increase the speed at sea—involving considerable capital investment and higher fuel costs—without trying to reduce time in port, since time could be decreased at much lower cost. I agree that the cargo winch operator ought to be able to see into the hold and should not have to rely entirely upon indirect command. Nowadays it is the normal practice to have two coupled derricks at work over one hatch, requiring two winches and operators, but it should not be difficult to connect the controls of both cargo winches so that only one operator was needed to handle them. This would quicken and cheapen cargo handling, especially if the operator had a clear view of the work in the hold.

In Fig. 4* the author gives the relation between the relative cost per ton-mile and the ship's speed, and I would point out that this relationship is not represented by a straight line, but by a curve. Recently, in the Yugoslav review *Brodograduja* (No. 4, 1955), I analysed the economic speed of a tramp ship of the same deadweight, and I came to the conclusion that the optimum speed increases with the increase of the ratio of permanent costs to fuel costs, and that to-day the optimum service speed of a 10,000 tons deadweight tramper varies from 14 to 15 knots (for very low permanent costs) to 15·75 knots (for very high permanent costs).

If we build a modern tramp ship with closed shelter deck, but so constructed that we can use her as an open shelter deck also, it could serve as a common tramper or as a liner tramp ship. Bearing in mind that it is usual to run the main propulsion motors at not more than 80 per cent of their output, and that at this reduced power they must give the required service speed, and also that, due to fouling and average weather conditions, the resistance of the ship will increase from 20 to 25 per cent above the resistance on the trial trip, I think that the output the author gives for case No. 4 is at the lower limit. Under these circumstances the output of the propelling machinery amounts to between 8000 h.p. and 10,000 h.p.

The advantage of the diesel engine is its low specific fuel consumption, which means higher net deadweight, greater hold capacity and cheaper operation. An output of 8000 h.p. to 10,000 h.p. can be achieved by a steam turbine installation, which is considerably cheaper to build, needs less room and has considerably lower weight, so that in this power range the diesel motor no longer has an advantage.

Mr. A. R. Mitchell: Towards the end of Part 3 of the paper the author draws attention to the relative influence, on the general overall economics of running the ship, of cargo handling and speed of turn round and economies in propulsion. This is most pertinent, as in many of the inquiries we receive for small vessels the speed/length ratio is much too high, resulting in high power, high fuel consumption, increased weight of machinery and fuel, with consequent loss of deadweight and increase in draught.

I am pleased that the author has qualified his enthusiasm for straight line forms by stating that no simplified form is worth incorporating in an expensive ship unless it can be shown to be fully the equal of a conventional form in every respect as well as being of lower inherent building and repair cost. There is a tendency by many engaged on the production side of shipbuilding to apply straight line construction to every type of vessel on the pretext of economy in construction, regardless of every other consideration.

I do not share the author's enthusiasm for the completely welded shell, for there is relatively little loss in power between the vessel with welded butts and riveted seams and the all-welded shell. For various constructional reasons, some builders still favour welded butts and riveted seams, and on both naval and merchant work at the present time riveted seams located above the waterline to act as crack arresters are frequently called for.

Professor Dr.-Ir. W. P. A. van Lammeren: To a certain extent I disagree with the author that it is customary on the Continent to adopt markedly "V"-shaped forebody sections in the range of block coefficients considered. The N.S.M.B. prefers moderately "U"-shaped forms in the forebody, and generally it is found from model experiments that there is little difference in the required effective horsepower for different shapes of forebody.

In my Fig. *A* the body plans are given of three models of the kind of ship in question having the same afterbody, but three different forebodies. All the models have the same curve of sectional areas and prismatic coefficients. From the corresponding e.h.p. and *C* curves in my Fig. *B* it can be seen that for the lower speeds the extremely "V"-shaped forebody gives slightly better results, whereas for higher speeds the "V" shape is definitely less favourable. On the other hand, the forebody with bulbous bow gives results worse than those of the normal form over the whole speed range. This is not surprising, for it is known that an appreciable favourable effect is not to be expected of a bulbous bow for speed/length ratios much smaller than 1·0. Though it is clear that under ideal conditions the differences in e.h.p. are insignificant, several ships with extremely "V"-shaped forebodies are known to suffer loss of speed, under bad

* Figure numbers refer to those given in the paper.

weather conditions, much more than that experienced by normal ships of the same kind. More information on this subject will become available as soon as the new sea-keeping laboratory of the N.S.M.B. is in full operation. I agree with the author that the longitudinal polar moment of inertia also plays an important part in the sea-keeping properties of ships.

As to the afterbody, the experience of the N.S.M.B. is that extreme " U " shapes have worse resistance properties than the corresponding moderate " U " shapes. For instance, of the two models in my Fig. *C*, the moderate " U " shape is from 1 to 4 per cent better in e.h.p. than the extreme " U " shape. However, this difference can be compensated if both models are fitted with their own optimum screw. Extremely " V "-shaped afterbodies always lead to bad results.

Dr. W. Muckle : The author gives in Fig. 1*A* the speeds of present-day tramp ships and we see that the majority are of the 15-knot type. In Fig. 1*B* he gives the D.W.C. of these ships. In deciding the most economical ship to build, perhaps one way of looking at the problem would be to consider how a shipowner can invest a certain capital sum in order to get the best return on his money. This might lead to a ship which could not be used to the best advantage in world trade, and probably such considerations as that would modify the final result.

In Fig. 4, where the author has developed the cost per ton-mile at different speeds, the curve is very flat, and although as drawn it shows a definite minimum point at 15 knots, there is considerable possibility of variation of speed without any great increase in the cost per ton-mile.

In the paper he mentions decreasing the resistance of the ship by means of model experiments. It is interesting that by carrying out model experiments and improving ship form you are improving the economics without increasing the first cost to any great extent, whereas with improved methods of cargo handling the first cost of the ship is increased.

I do not doubt that the future will see a great deal more of the longitudinally-framed cargo ship and I think the classification societies are coming round to this idea, particularly in welded ships. We know that with welding there is much greater initial deflection left in than with riveting, and longitudinal framing is a way out of this problem, apart altogether from the economic aspects. This is an important matter and may lead to the possibility of reducing plate thicknesses where one has to deal with compressive stresses.

In his typical sections for a 10,000-ton deadweight tramp with developable hull form it seems to me that from amidships to the sloping sides towards the ends there must be some twist in the plates somewhere. The two designs for the 11,000-ton deadweight tramp ship are interesting and comparable, in that they both have the same cargo deadweight, and therefore represent the results from different service speeds. It would be interesting to know how much the shipowner has to pay for the increase of speed, and to have comparative voyage estimates for the two ships, in order to obtain economic comparison.

Captain B. Lovricevic : Dr. Corlett's paper has aroused great interest among our naval architects and shipping people. I would like to refer to what Professor Silovic stated in his paper about the time spent in port, and to the statement by Dr. Corlett that the choice of deadweight is a difficult one, as it does not depend upon a basic mathematical analysis. Looking at the ship exclusively from the point of view of transport, I think it can be said that she is best employed when she achieves the maximum of ton-miles—and the amount of ton-miles achieved by a ship depends on the length of the voyage, on the time in port, speed at sea and the deadweight capacity of the ship. I think that a mathematical method should exist for finding the optimum relationship between these four values. The optimum correlation obtained in this way may not work satisfactorily when the ship is considered exclusively as a freight-earning unit, although a ship which is well employed from the technical point of view should give a good financial return. I think it would be worth while to know the optimum, however, for it could be usefully applied as a guide.

Regarding the mechanical steel hatch covers, although no Yugoslav ship is equipped with them, we intend to abandon the wooden hatch cover, for they wear out quickly and are a potential danger to the ship in bad weather and in the event of fire in the holds. We feel reluctant to use the mechanical hatch covers consisting of lids with hinges, as ships' officers have given unfavourable reports of them. They are a continuous source of trouble, and it is often necessary to reduce considerably the length of the hatch in order to install such covers. I think that steel or aluminium covers resembling pontoons, as used on American ships, provide a good solution of this problem, for with such an arrangement shifting beams and wooden hatch covers are not necessary.

Mr. C. F. Christensen : In 1941 my firm had to examine 116 ships, and from the reports we designed a cargo vessel. It has the engines aft, there is a raised tank top in No. 1 hold, and a low deep tank with hatches for the straight handling of cargo. The owners have not yet agreed to the use of electric cranes ; but they will come and will lead to further economies by reducing the time spent in port. For tramp ships we have come to the conclusion that simplicity is a necessity, since it is not easy to get first-class experienced engineers because the best go to the cargo liners operating from and returning to the United Kingdom. I do not think that Table IV gives a true picture of costs of the different kinds of main engines, because a heavy fuel oil installation costs up to £14,000 extra. There is extra weight, increased maintenance requiring an extra man, and there is more wear on machinery calling for more spare parts to be carried.

Mr. J. D. Calder : My Yugoslav friends are still faced with the task of rebuilding their coastal fleet, and one or two questions have been put to me about the suggested designs for the 450-ton deadweight coaster and the 3000-ton deadweight cargo tramp ship. For example, in the case of the 450-ton coaster, there have been comments on the block coefficient of 0·675, and it seems that the speed/length ratio with that block coefficient is rather unusual. Both these represent types which have been built extensively in Yugoslavia since the war, and if Dr. Corlett can make any comments they will be appreciated.

Mr. R. B. Shepheard : In regard to structural arrangements and longitudinal framing, I endorse what Dr. Corlett has said. In the cargo ship it has become increasingly obvious that longitudinal framing at the deck and at the bottom is the only right and proper form of construction. I say that because Dr. Muckle indicated that the classification societies are only now beginning to appreciate the advantage of this form of construction. I have been interested in this for a number of years, and Lloyd's have done their best to experiment with scantlings towards adopting what is becoming now standard practice.

About the design for a 450-ton coaster, I would like to ask about the arrangement of the machinery space, concerning which there may be difficulties in respect of ventilation and access to the main engine. As to the ballasting, I notice there is an adequate forepeak, but there seems to be no water ballast capacity right aft, and one wonders whether the ballast draught, particularly aft, would be adequate when the ship was light.

Captain Lovricevic has already referred to the steel hatch covers described in the paper, and in the design of these small ships these large covers, split into two and spread fore and aft, mean that there is some restriction in the length of the hatches, which would not arise if the pontoon type of steel cover were used.

With regard to the designs for the 11,000-ton slow and fast tramp ships, is Dr. Corlett satisfied that there is good visibility over the forecastle head with the bridge place aft, when the ship is light and in ballast ?

Monsieur A. Augustin-Normand : We have been using a new kind of engine in France on dredgers and on two small cargo ships, of 900 tons, running between Bordeaux and Hamburg ; I think that up to now they must have covered 6000 miles. Those engines can burn all sorts of fuel ; in the United States they have used the worst fuel possible and the engines were still very successful.

Dr. Corlett, replying to the discussion, said : Professor Silovic mentioned coupled derricks and it is quite a point that one operator should be in complete control of the entire operation. In regard to his remarks on 8000–10,000 h.p. engines, of course, we are getting out of the tramp ship range here and coming to the cargo liner. In some recent cases we have had to cost installations giving approximately 10,000 s.h.p., and our experience is that there was very little to choose between the costs of diesel machinery and steam turbines ; but in order to get reasonable fuel consumption we were using advanced steam conditions in the turbine.

In reply to Dr. Muckle, I am afraid that many shipowners work in an *ad hoc* way in deciding what they are going to have. Some seem to decide mainly upon their own feelings rather than on any detailed analysis as to what size and speed of ship they should have. Dr. Muckle's interpretation of Fig. 4, showing the relative cost per ton-mile for different speeds for a modern diesel ship burning boiler oil, is correct. There would be very little disadvantage for that particular ship in operating at speeds between 14½ and 15½ knots. In connection with Fig. 5, he suggests that there should not be twist in the plating in coming from the straight side to the conical stern. In fact, the junction between the flat side and the conical stern will not lie along a section at right angles to the ship's axis ; it will be at an angle probably of the order of 40 deg. from the horizontal.

I agree with Captain Lovricevic that the deadweight choice is available by computation ; but I point out that that applies more and more to ships which have regular voyages.

This problem of getting good engineers for service on tramps is very serious. There are owners using triple expansion steam tramps simply because they cannot get good engineers. It is a world-wide problem and is particularly troublesome in Britain and, of course, almost prohibitive in America. It would seem to be a very retrograde outlook to build ships which are of proved lower efficiency because we cannot get good engineers.

The 1955 Motor Show

No. 1

THE International Motor Show, which opened, as recorded in last week's issue, on Wednesday, October 19th, is again drawing crowds of interested visitors, among them a considerable number of foreign buyers, to the spacious exhibition hall at Earls Court, London. Not less than 187 British cars and 100 of their competitors from overseas countries are on show, a clear demonstration that the exhibition is not merely a shop window for British buyers to choose a new car, but a display of the cars of the world for all the world's buyers. It is here where the fight for sales begins, and for this reason this year's Motor Show should be considered not only from a technical point of view, but with the object of assessing the British motor industry's competitive strength.

Contrary to our usual practice of giving a survey of the new British motor-cars at the opening week of exhibition, we intentionally refrained from doing so this year ; we wanted more time between the preview and our report going to press for a closer examination of our latest designs in comparison with those of our strongest foreign competitors. Further, it was to be expected that at least two new cars would not be on show before the opening day, and we wanted to include those in our survey, hoping that at least one of the thirty British manufacturers, making about 130 different models, might come forward with a new construction to counteract the impact made on world's markets by the numerous technical innovations incorporated in most of the latest Continental designs.

In this respect, however, we have been disappointed because none of the latest British exhibits shows anything of that adventurous spirit which, still considered " unorthodox " in this country, has for some considerable time become the generally accepted design standard on the Continent. Although the number of different makes produced in Great Britain is bigger than that in any other country of the world, the basic principles of automobile construction are still as uniform as they used to be in pre-war days. There has been no attempt to break away from conventional practice, no indication even that our industry might consider the adoption of such principles as independent all-wheel suspension, air-cooled and two-stroke engines, front-wheel drive and rear-engine mounting. This marked hostility to ideas which are characteristic of the flexibility of the Continental automobile industry and which, to a great extent, account for its growing influx into world markets, will have to cease sooner or later if Britain wants to maintain its position as the greatest motor exporting country of the world. Considered from this point of view, this year's new cars should probably be regarded not so much as the best possible efforts the British motor industry has to offer, but as products of a transitory phase to give our manufacturers time for developing designs, which, by sheer ingenuity of their engineering principles, could recover lost markets.

These remarks are not intended to underrate the value of latest show models as sales-winning products. On the contrary, within the limitations imposed by their general conception, they represent excellent examples of contemporary British automobile construction and, as far as detail design of major components (in particular engines) and body structures is concerned, they are second to none of their foreign competitors. The styling also has been greatly improved—with some marked approach to Swiss and Italian examples. This in itself constitutes a major selling point, particularly at a time when the public, rightly or wrongly, takes mechanical perfection almost for granted and tends to buy cars mainly for their æsthetic appeal. In these circumstances, we believe that the new cars will indeed prove to be "sales-winning " products, and that is the reason why, in our appraisal last week of the Motor Show as a sales-stimulating display, we considered the prospect with moderate optimism. We are, however, somewhat concerned about the price increases announced by a number of manufacturers early this month, i.e. at a time when several French and Italian firms had just reduced the prices for their popular models. Undoubtedly, these increases might be justified because of rising wages and the higher cost of some raw material ; on the other hand, they may constitute a major handicap in highly competitive markets where prices are more closely studied than specifications.

It also has been our practice in recent years to analyse our impression of the Motor Show by giving a short survey of the prominent trends which either govern the present design or which give an indication of the direction that future development might take. This year we are faced with one difficulty, namely, to decide which principles adopted in the construction of the new cars might have some definite bearing upon the design of the inexpensive, mass-produced family saloon. As it happens, practically all these cars, with the exception of the Standard " Vanguard III," are not being made in large-quantity production. They are mostly specialised high-performance cars of the medium or higher price class and have been built either to replace models of limited sales appeal or, if made to supplement an existing manufacturing programme, for the purpose of attracting a wider circle of customers by the offer of higher economy and lower first cost. All these cars, however, are designed and built for some clearly defined purpose and differ considerably in their basic conception. If any common tendency is to be found at all, it is the increased adoption of integral body structures and the use of engines of higher specific output. The latter tendency which is also prevalent in Continental design might easily spread to the inexpensive class of small and medium-sized mass-produced cars.

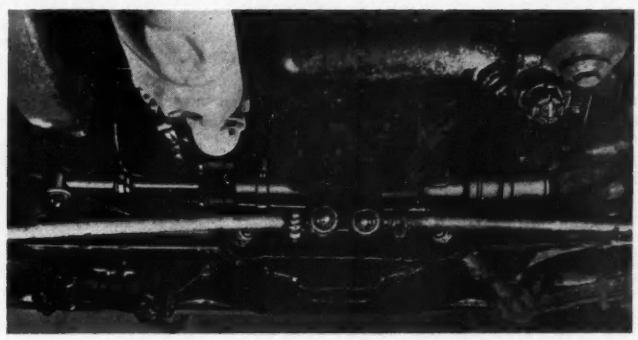


Fig. 2—A hydraulic ram carries the inner ends of the divided track rod on the Armstrong Siddeley " Sapphire "

Other technical features, such as over-drive gears, servo-brake mechanism, automatic and semi-automatic transmissions, however, are hardly applicable for cars in which low first cost is the primary consideration. What could happen is that the now generally realised value of the over-drive for fuel economy may make designers more conscious of the importance of a four-speed gearbox with positive-lock synchronisation and of the necessity for a more careful matching of the gear ratios with the torque characteristic of the engine. A combination of these two desiderata would be a further step in the direction of a simple and inexpensive form of gear-change in which the clutch operation could be effected by means of centrifugal, pneumatic or electro-magnetic action.

In view of the rather heterogeneous character of the latest British show models we refrain from further comments upon common tendencies and turn to a short description of their specifications.

Two new models on the stand of Armstrong Siddeley Motors, Ltd., the " Sapphire 234 " and the " Sapphire 236," have attracted attention. Both cars are identical in their appearance and in their general layout, but the " Sapphire 234 " has a 2·3 litre, four-cylinder engine and the " 236 " has a six-cylinder engine of the same capacity (Fig. 1). The cars are of conventional design, i.e. they have a strong cross-braced chassis with wishbone-coil-spring suspension at the front and semi-elliptic leaf springs at the rear. The body consists of a steel skeleton frame, panelled throughout with light-metal sheeting, and is mounted on the chassis on rubber pads. The front and rear wings are of steel, detachably bolted to the body structure for easy repair. The cars are fitted with large brake drums, brake operation being effected by oil pressure, assisted by a Clayton-Dewandre booster unit. With a wheelbase of 9ft 3in, they weigh only 26 cwt, as a result of the extensive use of light-metal for the body panelling.

The engine of the type " 236 " is a simple six cylinder of 70mm bore and 100mm stroke, developing 85 h.p. at 4400 r.p.m. The four cylinder engine of the type " 234 " has been

Fig. 1—The Armstrong Siddeley " Sapphire 236 " has the engine of the former 2·3 litre models, developed to give 85 h.p. at 4400 r.p.m.

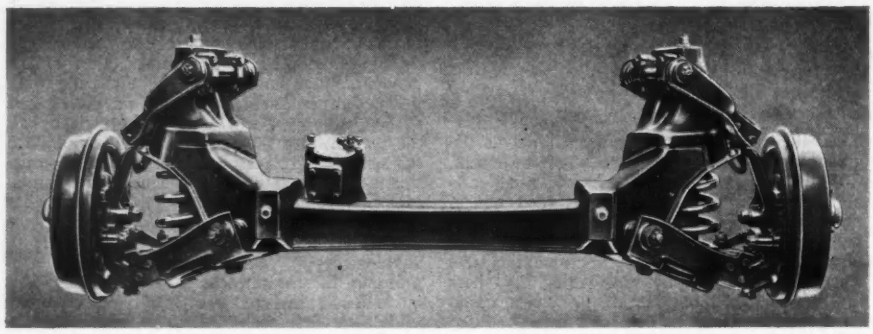


Fig. 3—The 2·4 litre "Jaguar" continues the use of ball-joint steering

developed from the well-known six-cylinder 3·4 litre engine of the "Sapphire 346" and has the same bore and stroke (90mm by 90mm) as the latter. It might be recalled that the 3·4 litre six cylinder which was described in THE ENGINEER of November 7, 1952, has a hemispherical combustion chamber with the push-rod operated valves inclined each at an angle of 35 deg. relative to the cylinder axis. By suitable modifications of the design, in particular by raising the compression ratio from 6·5 : 1 to 7·5 : 1, stiffening the crankcase and the valve-operating gear, it has been possible to attain with this new four cylinder an output of 120 h.p. at 5000 r.p.m., i.e. more than 50 h.p. per litre, compared with 125 h.p. at 4700 r.p.m. of the latest version of the six cylinder engine.

The transmission layout follows orthodox practice, employing a single-plate dry clutch and a fully synchronised four-speed gearbox, but the "Sapphire 236" is fitted as standard equipment with the "Manumatic" vacuum-assisted gear-change which provides two-pedal control. Two other cars on the Armstrong Siddeley stand, both of the type "Sapphire 346," are also fitted with gear-change aids, one with the combination of a centrifugal clutch and a preselective epicyclic gearbox, the other with a fully automatic transmission. Both cars are available with new optional extras, namely, power-assisted steering, adjustable ride control for the rear suspension and electrically-operated windows (Fig. 2).

The new 2·4 litre "Jaguar," first announced at the beginning of this month, is the centre of interest at the stand of Jaguar Cars, Ltd. It is the first car of this firm built in integral construction and greatly appeals to the eye because of its clean lines. Moderately priced and economical in operation, it is intended for a much larger public than exists for the 3·5 litre "Jaguar" while still maintaining the high performance and the sporting character of the bigger car.

The unitary body construction was adopted to keep the weight of the car down to 25 cwt, whilst retaining maximum structural strength and rigidity. The car has a wheelbase of 9ft and provides comfortable seating space for four or five passengers with adequate luggage accommodation. Owing to the shorter wheelbase of the new model the Mark IV type front suspension, employing torsion bars, had to be replaced by a wishbone-coil-spring layout. The wishbones, coil springs and telescopic dampers are assembled on a pressed steel cross member, (Fig. 3). which is attached to the body structure by means of flexible vee-shaped rubber mountings. The same principle of insulating the body from road-excited noise and vibrations by means of flexible rubber mountings has been applied for the rear suspension. Long cantilever springs carry the rear axle in normal rubber-bonded bushes ; the centre parts of the springs are encased in rubber blocks, attached to the box-sectioned length members of the body structure, and the front ends are mounted on longitudinally flexible rubber pads. The torque reactions are taken by two forward-facing radius arms, joined at the front end to a cross member underneath the back of the rear seats (Fig. 4). The lateral location of the rear axle is effected by means of a short Panhard rod.

The six-cylinder 2·4-litre engine of the new model (Fig. 5) has been developed from the successful 3·5-litre twin overhead camshaft engine of the "XK" model. It has the same cylinder bore of 83mm, but the stroke has been reduced from 106mm to 76·5mm, thus enabling the engine to run at a higher speed without causing a higher rate of cylinder wear or imposing additional stresses on bearings, crankshaft and connecting-rods. The 2·4-litre engine has a compression ratio of 8 : 1 (optionally 7 : 1) and develops 112 h.p. at 5750 r.p.m., compared with 190 h.p. at 5500 r.p.m. of the 3·5-litre engine. The layout of the transmission is conventional, the torque being transmitted from the engine via a single dry plate clutch, a synchronised four-speed gearbox and an open propeller shaft to the hypoid rear axle. The hydraulic brakes are servo-assisted.

Another car in which the adoption of unit construction has resulted in considerable weight saving is the "Vanguard III" of the Standard Motor Company, Ltd. The "Vanguard," which since its introduction in 1947, has been restyled once two years ago, now appears in improved form (Fig. 6), embodying such useful details as large curved rear windows, a low sloping bonnet and a spacious luggage locker. Compared to the "Vanguard II," which it replaces, the wheelbase has been increased by 6in to 8ft 6in, thus reducing any tendency to pitching. The wishbones, coil springs and telescopic dampers are assembled on a stiff cross member which is attached to the body frame at four points with rubber insulation at each. The wheels pivot on ball joints at the top and in threaded bushes at the bottom. The box of the recirculating steering layout is mounted on the detachable cross member and so is the idler ; a universal joint connects the steering box with the steering shaft.

The 2-litre o.h.v. four-cylinder engine, though remaining basically unchanged, has been modified. With bigger inlet valves, improved port design and a compression ratio of 7·5 : 1 it now develops 62 h.p. at 4000 r.p.m., i.e. about 5 h.p. more than the previous engine.

Apart from the 2·6-litre "Isis" saloon, which Morris Motors, Ltd., introduced some months ago, the only new car built by firms belonging to the British Motor Corporation is the M.G. type A of M.G. Car Company, Ltd. It replaces the well-known former M.G. sports car, which for many years had been produced without any notable alteration and, consequently, did not conform with modern standards of appearance and performance. The "M.G.A." is a two seater, seen in Fig. 7, not primarily designed for competition work, but more for ordinary sporting tourists and, for this reason, it is equipped with a moderately roomy luggage boot which also houses the spare wheel. The front suspension employs wishbones of unequal length and coil springs, while the three-quarter floating hypoid rear axle is carried by semi-elliptic leaf springs. In accordance with the sports cars usual practice, the "M.G.A." has a four-speed gearbox with central gear shift lever and hydraulically operated brakes with large brake drums. The engine is a twin carburetter version of the 1·5-litre series "B" unit of the British Motor Corporation, i.e. basically the same standard unit as mounted in all other 1·5-litre cars made by the Austin-Nuffield group of companies. By raising the

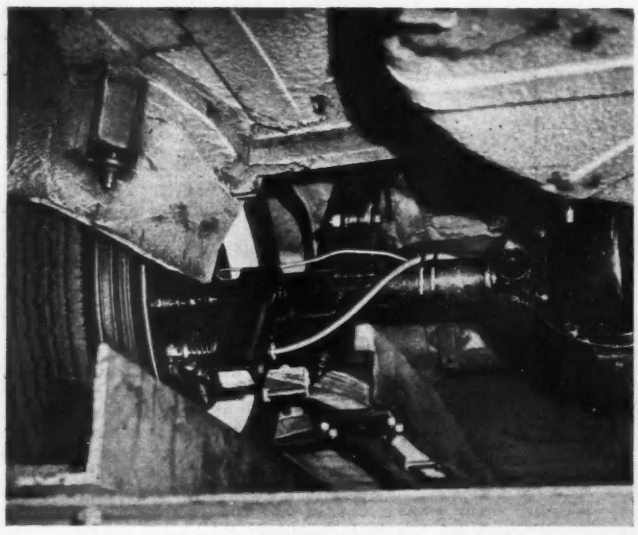


Fig. 4—The 2·4 litre "Jaguar" has rear suspension by cantilever springs and trailing links

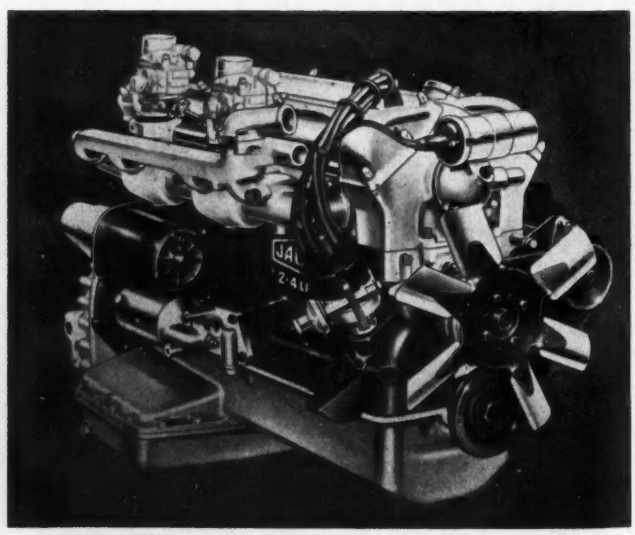


Fig. 5—The 2·4 litre "Jaguar" engine is a short-stroke version of the 3·5 litre "XK" model

Fig. 6—The Standard "Vanguard III" has an integral steel body shell with a wheelbase 6in longer than that of the earlier cars

Fig. 7—The "M.G.A" model has a family likeness to the Austin-Healey

Fig. 8—The Sunbeam "Rapier" has a 1·4 litre engine giving 57 h.p. at 5000 r.p.m.

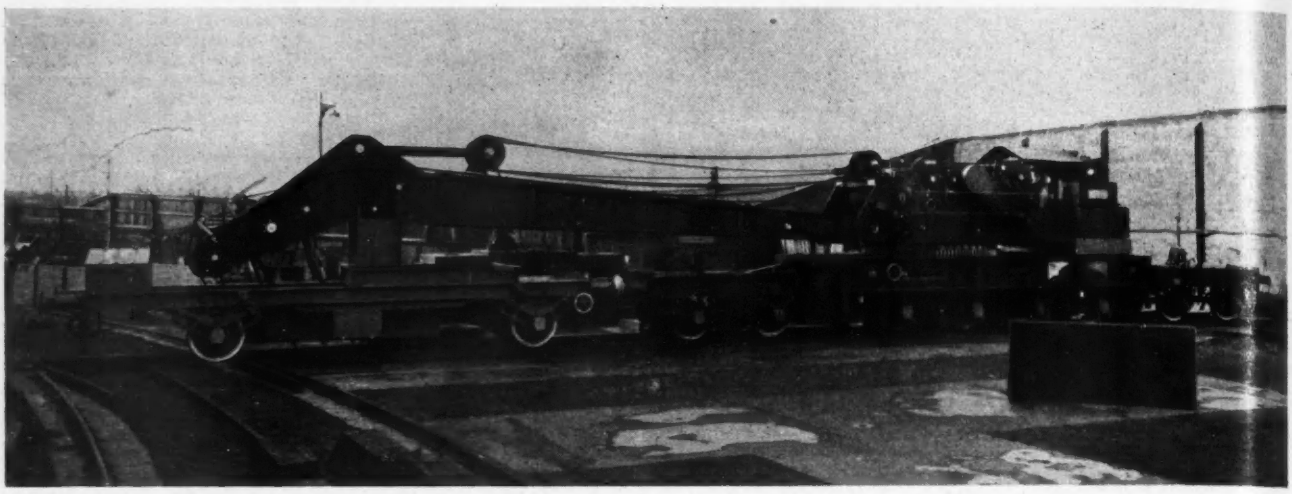
engine speed from 4200 r.p.m. to 5500 r.p.m. and by increasing the compression ratio from 7·2 : 1 to 8·3 : 1 the output of 50 h.p. of the standard engine has been raised to 68 h.p., with a consequent shifting of the maximum torque from the original speed of 2100 r.p.m. to one of 3000 r.p.m. The "M.G.A." has a dry weight of 17 cwt and is designed for a maximum speed of about 90 m.p.h.

A similar method, namely, making use of an existing engine, designed primarily for standard production cars, for the purpose of adapting it to a specialised high-performance car, has been employed by Sunbeam-Talbot, Ltd., a firm belonging to the Rootes Group. The new Sunbeam four to five-seater saloon "Rapier" has a 1·4-litre, four-cylinder o.h.v. engine which is basically identical with that of the latest "Minx" of Hillman Motor Car Company, Ltd., another member of the Rootes Group. The "hotting-up" process of the engine here has resulted in a power increase from the original 43 h.p. at 4400 r.p.m. to 57 h.p. at 5000 r.p.m. Apart from the usual increase of speed and compression ratio (from 7 : 1 to 8 : 1) other modifications include an aluminium inlet manifold from which the thermostatically controlled flap valve is omitted, and light tubular push rods. The "hot spot" at the bifurcation of the inlet manifold has been discarded, but a certain degree of preheating is provided by heat transferred from the exhaust manifold which also is made of light metal.

The "Rapier," a hard-top, two-door saloon (Fig. 8), is designed as a high-performance car with a maximum speed in the region of 90 m.p.h. Harmonious in its proportions from the sloped bonnet to the wide, swept-round rear window, it conveys a hint of Continental styling. Good all-round visibility is provided by the lack of the central door pillar ; the windows and the curved rear light can be completely lowered inside the body, giving an almost open-car effect. The body is built in integral construction characterised by two substantial cross members which at their outer ends are tied into the body sills and, strengthened by the floor panels, merge into the deep propeller shaft tunnel. The floor line is recessed well below that of the sills, so that the passengers step down into the interior. This permits a lowering of the overall height to less than 5ft, without loss of head and leg room, and gives a low centre of gravity. The front suspension follows the now almost universal practice of having the wishbones, coil springs and, in this case, the anti-roll stabiliser mounted on a pressed box-sectioned member, attached to the body by means of rubber-bushed bolts. A four-speed gearbox is used in connection with an overdrive operative in top and third gear ; the overdrive, though housed in a separate casing, is a standard fitting and not, as customary, an optional extra.

Concluding our report of the new British cars at Earls Court, we should like to mention one more car, the "Hunter 75," of Singer Motors, Ltd., which has the same dimensions, namely, a bore of 73mm and a stroke of 89·5mm, and also the same cylinder block as the previous "Hunter" engine. Instead of the former single overhead camshaft and the rocker-operated valve assembly, the new cast iron cylinder head carries two camshafts and the direct-actuated valve gear. The combustion chambers are hemispherical and the valves are arranged at an included angle of 90 deg., equally spaced on either side of the cylinder axis. The camshafts and the valve tappets are carried in a separate cast iron housing which is bolted to the cylinder head and is covered by a light-metal casing. Individual inlet ports are used, and the inlet manifold (water jacketed for the preheating of the charge) carries two Solex down-draught carburettors. For the camshafts a two-stage duplex chain drive is used at the front of the engine ; the second stage, which drives both camshafts, is rather complex in its layout, employing not less than three idler sprockets and one chain damper. Nevertheless, this mechanical effort seems justified by the high output of the engine, which develops 75 h.p. at 5250 r.p.m. (compared to 48 h.p. at 4200 r.p.m. of the previous type) and has the useful brake mean effective pressure of 140 lb per square inch at the comparatively low speed of 3000 r.p.m.

(*To be continued*)



Crane with relieving bogies and match-truck coupled. The ramp to draw the articulated jib off its pivot is not fitted

Railway Breakdown Crane

THE first of seven 75-ton steam breakdown cranes ordered by the Indian Government Railway Board from Cowans, Sheldon and Co., Ltd., Carlisle, has now been completed. These cranes are to run on 5ft 6in gauge track, with a standard load gauge of 14ft and an axle loading, in a train, of 16 tons. The general arrangement of the vehicles is illustrated here and the performance is given in the table.

A heavy steel centre casting carries the turntable and the underframe is riveted up from rolled steel sections. The four axles run in white metal on gun metal bearings, the cast steel boxes carrying conventional semi-elliptic springs : the main leaf is slotted at each end to allow the single shackle to drop to the frame brackets. Backing screws are provided to restrict deflection of the springs when hoisting.

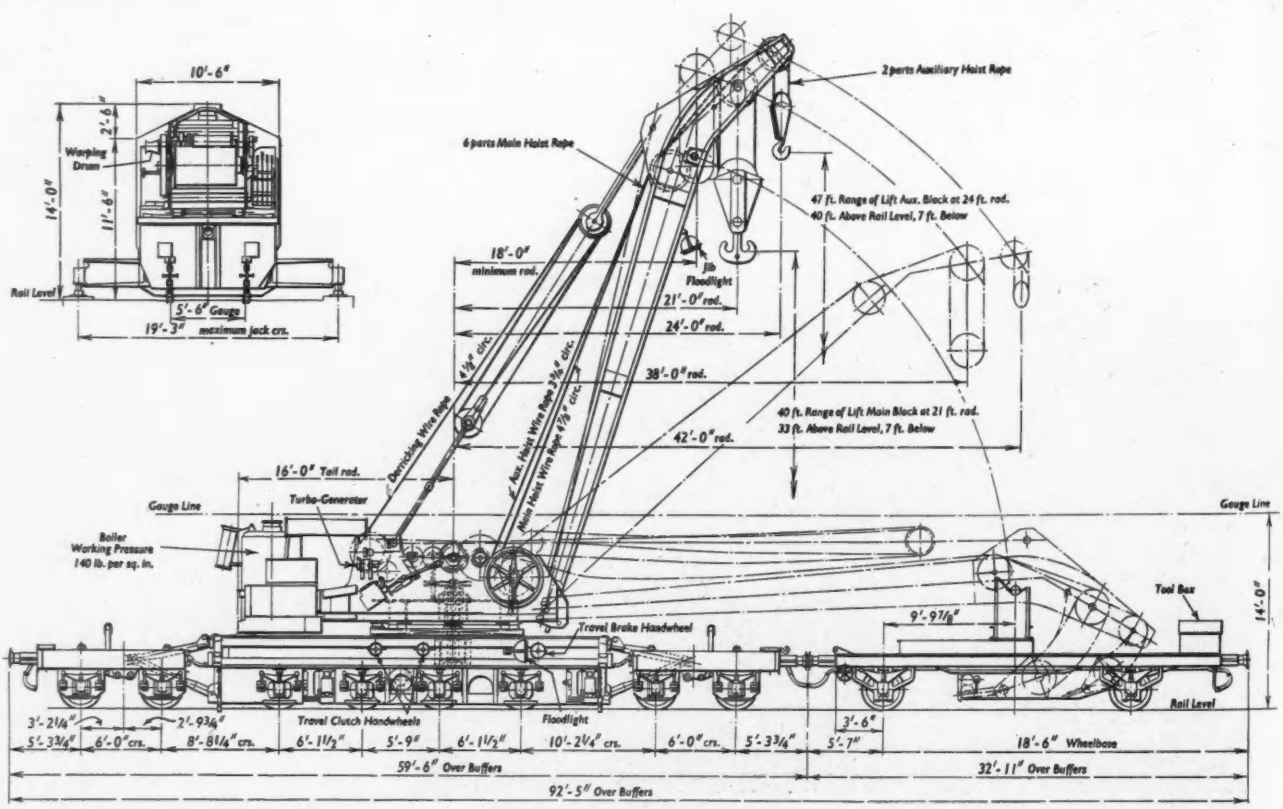
The wheels are solid steel discs and can be turned down for tyres to be fitted when worn.

The superstructure, consisting of two thick steel plates joined by steel stretchers, turns on a 9ft diameter ring of forty-eight steel rollers, a massive centre pin locating it : for towing it can be locked in the fore-and-aft attitude. At one end, above a set of cast counter-weights, there is mounted a Hopwood multi-tubular boiler, working at 140 lb per square inch, with a normal rating of 890 lb per hour and a hard steaming output of 1150 lb per hour. The boiler is coal-fired, 10 cwt of fuel and 250 gallons of water being accommodated beside it ; its chimney is hinged and a damper provided. The main power unit has two 8in by 14in cylinders, reversing by means of Walschaerts valve gear: this engine powers five motions. The main hoist block is lifted by six parts of rope to one on the barrel, for which a " lock on " foot brake is provided. On the pinion shaft of this barrel is that for the auxiliary hoist, with a velocity ratio of two to the hook, and the same shaft carries a warping drum. Derricking of the jib is given by a ten-to-one hoist from a drum driven by worm gearing, and is arranged to be self-sustaining under all conditions of loading.

The revolving motion is obtained by a double cone friction clutch driving a pinion engaging with spur teeth cut on the lower track of the turntable.

Travelling of the carriage is effected by driving the two centre axles by bevel gearing and a shaft through the centre pin : sliding pinions in the underframe are freed by handwheels when the crane is to be towed. In addition, the boiler provides steam for a turbo-generator supplying the jib and carriage floodlights, and for a brake system on the running gear controlled by the driver.

The jib is of swan-necked pattern and at its



General arrangement of railway breakdown crane

lower end each side member ends in an open slot. When the jib is lowered into the match truck, pins on each side opposite the luffing anchorage ride outward on ramps on the match-truck trestle, thus drawing the jib away from the

TABLE—*Lifting Capacity*

Crane on level track.
With propping beams fully extended and in service:
75 tons at 21ft radius } Main block
35 tons at 30ft radius }
23 tons at 38ft radius } Main block
15 tons at 42ft radius ... Auxiliary block

Crane standing free-on-rails:
18 tons at 18ft radius ... Main block
15 tons at 21ft radius }
12 tons at 24ft radius } Auxiliary block
7 tons at 33ft 9in radius }
4½ tons at 42ft radius }

Crane on super-elevation not exceeding 5in. (Radii as measured when crane is standing level.)
With propping beams fully extended and in service:
53 tons at 21ft radius } Main block
29 tons at 30ft radius }
20 tons at 38ft radius } Main block
13 tons at 42ft radius ... Auxiliary block

Crane standing free-on-rails:
13 tons at 18ft radius ... Main block
11 tons at 21ft radius }
9 tons at 24ft radius } Auxiliary block
5 tons at 33ft 9in radius }
3 tons at 42ft radius }

Range of lift:
Range of lift of main block at 21ft radius, 33ft above rail level and 7ft below.
Range of lift of auxiliary block at 24ft radius, 40ft above rail level and 7ft below.

Speeds:
Main lift ... ... 75 tons at 9 f.p.m.
35 tons at 18 f.p.m. (fast gear)
Auxiliary lift ... 15 tons at 45 f.p.m.
7 tons at 90 f.p.m. (fast gear)
Slewing ... ... 75 tons at 1 rev. in 2 min.
Derricking ... Running height to minimum radius in about 3½ min.
Travelling ... 15 tons at 220 f.p.m.

superstructure until the pivot pin is near the mouth of each slot: in this position, the jib can articulate with respect to the carriage as corners are negotiated.

Between match-truck and crane runs one of the two relieving bogies. Each carries the joint of a strut and a tie which abut and couple flexibly on to the crane carriage. The joint can be raised in the bogie (thus transferring part of the crane weight to the bogie) by a linkage and locked by a pin for travelling: the linkage is raised by a hydraulic jack or, since a mechanical advantage is provided, by the crane's own hoist. Timber-faced buffing blocks are fitted each side to crane and bogie. Vacuum hose couplings for braking in a train are provided.

When the crane is to be operated statically, as it must be for all lifts exceeding 18 tons, rail clips are used. Blocking beams can be run out both sides at roughly equal distances from the superstructure pivot by means of rack and pinion feeds, and screw jacks support the frame on cast steel shoes.

Each crane is assembled completely in the works and on a recent visit we witnessed the trials of the first, which included overload tests in the free-on-rail and propped states under both level and super-elevated track conditions: the tipping load is never less than 128 per cent of the working load. Travelling trials were also performed, curves of minimum radius being available. One further crane, somewhat lighter, has also been ordered by the same customer.

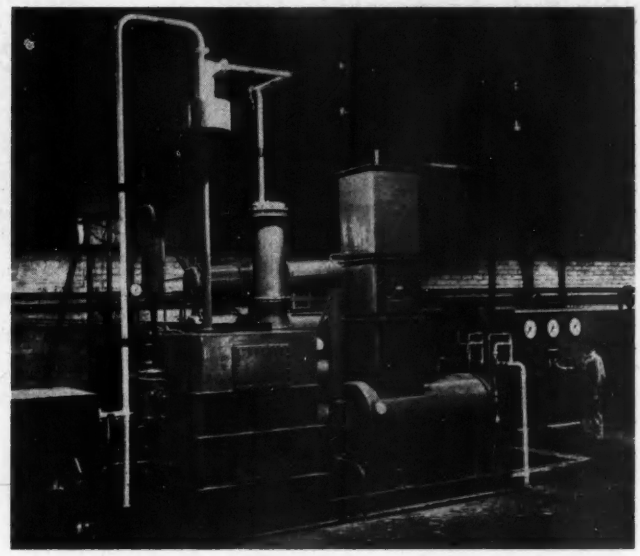


Fig. 2—Atmosphere generating plant of electric heat treatment furnace

Heat Treatment Plant for Seamless Tubes

IN the heat treatment of carbon- and low-alloy steels a controlled atmosphere is frequently employed. The following details concern a plant for the heat treatment of seamless steel tubes, installed in the works of Accles and Pollock, Ltd., Oldbury, Birmingham, by the Incandescent Heat Company, Ltd., and its associate company, Metalectric Furnaces, Ltd., of Smethwick. The equipment comprises a continuous mesh belt-conveyor furnace with electric heating elements and a "Hi-Nitrogen" atmosphere generator.

Fig. 1 gives a general view of the furnace, looking from the loading end where 16ft tubes can be loaded directly on to the roller table, which is driven at variable speed from the same motor as the conveyor belt so as to handle up to 1000 lb per hour. The heater elements, totalling 140kW, are accessible from outside the furnace without dismantling the structure or disturbing the conveyor. Automatic temperature control has been provided between 750 deg. Cent. and 1080 deg. Cent., the higher temperature being necessary for stress relieving of low alloy steel tubes. Effective work width of this furnace is 2ft. Immediately adjoining is the cooling tunnel, with water-cooled sections. The tubes finally emerge on a roller table similar to that at the loading end.

Although the entire mechanism, heaters, rollers, &c., is readily accessible for repairs, the furnace section forms a completely gas-tight structure with flexible seals at entry and exit to retain the atmosphere, so as to keep gas losses to a minimum.

The atmosphere generator, shown in Fig. 2, is capable of supplying 3000 cubic feet per hour of prepared gas, the composition being adjustable between ½ per cent oxygen excess and 6 per cent combustibles excess (CO plus H_2), to meet the needs of the steels under treatment. The remainder of the gas is nitrogen, which is free from oxygen, carbon dioxide and sulphur, and of a dryness corresponding to a dewpoint of −40 deg. Cent. In preparing the atmosphere town gas is used, burnt, with a carefully controlled air/gas ratio, and unwanted constituents are selectively removed.

Using a typical town gas, and assuming full combustion with no residual oxygen or inerts, the chemical fractions are given in the following table.

Average composition of town gas, per cent	Cubic feet per 100 cubic feet town gas			
	CO_2	H_2O	N_2	Oxygen required
O_2 1·0 ..	—	—	−3·7	−1·0
CO_2 4·0 ..	4·0	—	—	—
C_2H_2 2·5 ...	7·5	7·5	42·5	11·3
CO 21·5 ...	21·5	—	40·7	10·8
H_2 45·5 ...	—	45·5	86·0	22·7
CH_4 16·0 ...	16·0	32·0	121·0	32·0
N_2 9·5 ..	—	—	9·5	—
100·0 ...	49·0	85·0	296·0	75·8

It will be seen that 100 cubic feet gas requires 75·8 cubic feet oxygen or 364 cubic feet of air. This gives an air/gas ratio of 3·64/1, with a calculated calorific value of 464 B.Th.U./cubic feet. In this way 296 cubic feet of nitrogen result from 100 cubic feet gas plus 364 cubic feet air, and to obtain 1000 cubic feet of nitrogen requires $\frac{100 \times 1000}{296} = 338$ cubic feet gas and 1230 cubic feet air. The nitrogen contains slight traces of sulphur, present in the town gas as organic compounds, and changed by combustion to sulphur dioxide. The carbon dioxide is removed by bubbling the products of combustion through a solution of monoethanolamine with which it combines in a reversible manner. Subsequently the monoethanolamine can be reclaimed and also, if required, the carbon dioxide, which is easily purified. This process will now be described with reference to the flow diagram, Fig. 3, overleaf.

The gas is driven through the plant by a booster (11) which, by pressurising the system, also prevents ingress of air.

The burner system is specially designed with a

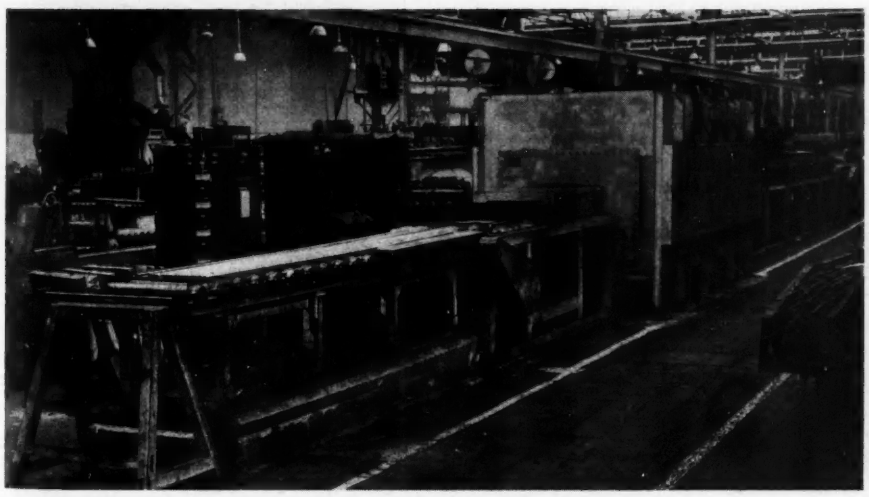


Fig. 1—140kW electric heat treatment furnace with a capacity of 1000 lb per hour

slightly flared refractory combustion tunnel. This is to avoid soot formation when burning rich mixtures. Combustion is completed in an immersion heater in the reboiler (21), to utilise the heat of combustion for boiling the CO_2-absorbing liquid, monoethanolamine. After burning, the gases are cooled in a shell-and-tube cooler (15) and then pass through a centrifugal liquid extractor (16) where the water of combustion and most of the sulphur dioxide held in solution are rejected.

The cooled gases are introduced into an absorption chamber (18) where they pass through porous plates and bubble through the liquid in a diffused cloud to absorb completely the carbon dioxide. The chemical reaction of carbon dioxide with monoethanolamine produces monoethanolamine carbonate and bicarbonate with 100 per cent absorption of CO_2.

The remaining sulphur dioxide is also taken up by a similar reaction and the emerging gas is practically pure nitrogen if full combustion is used. As the reaction is exothermic it is necessary to cool the gas to avoid loss of liquid, as the turbulence above the liquid loads the gas above saturation point. Any liquid carry-over is taken back into the system by flooded syphon. Gas drying is done in two stages by preliminary refrigeration to give a standard dewpoint, followed by a twin chamber activated alumina "Hydromaster" gas drying unit.

The carbon dioxide-laden monoethanolamine is continuously extracted from the absorber by pumps and is circulated through the heat exchanger (24) to a stripping tower (22) which allows a slow trickle back to the reboiler against the rising boiler vapour, which passes into the condenser (23). This converts the liquid back to monoethanolamine, and frees CO_2 and the trace of SO_2 which pass out of the plant at *K*. The liquid is returned to the circuit by a syphon return *L*, the full reaction being :—

$$2NH_2\,CH_2\,CH_2\,OH + H_2O + CO_2 \rightleftharpoons (NH_2\,CH_2\,CH_2\,OH)_2\,H_2\,CO_3$$

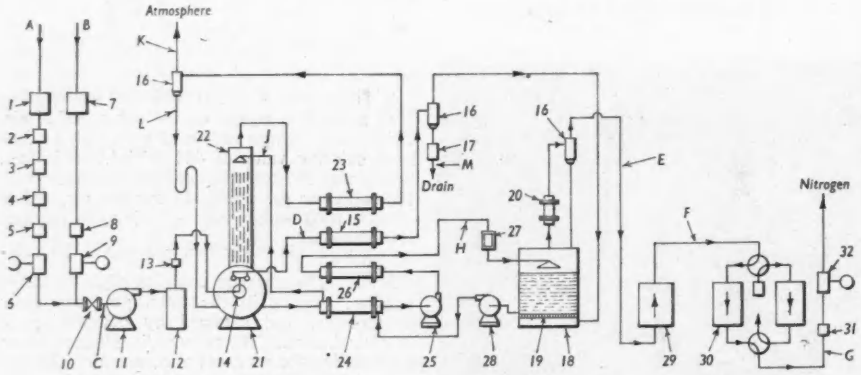
20 deg. Cent. (first absorption).

$$(NH_2\,CH_2\,CH_2\,OH)_2\,H_2\,CO_3 + H_2O + CO_2 \rightleftharpoons 2NH_2\,CH_2\,CH_2\,OH\,.\,H_2\,CO_3$$

60 deg. —100 deg. Cent. (final absorption and reactivation).

An interesting detail of the plant is the control of liquid levels in the vessels by contact electrodes. These work at low voltage alternating current and control the pumps and flow valves through relays. One of the combined sight glasses and electrode boxes is visible on the boiler in Fig. 2. The control panel shown on the right mounts flow meters for air, fuel gas and atmosphere gas, together with the reactivation pyrometer and selector switch, and the push buttons for motors and electrical ignition.

Controls are interlocked so that the plant can only be started and stopped in correct sequence.



EQUIPMENT

1. Gas filter
2. Gas pressure switch
3. Gas solenoid valve
4. Zero governor.
5. Gas limiting orifice valve
6. Gas flowmeter
7. Air filter
8. Air limiting orifice valve
9. Air flowmeter
10. Non-return valve
11. Air-gas booster
12. Oil trap
13. Flame Trap
14. Burner
15. Gas cooler
16. Gas liquid separator
17. Steam trap
18. Carbon dioxide absorber
19. Porous plates
20. Gas aftercooler
21. Reboiler
22. Stripper tower
23. Condenser
24. Amine heat exchanger
25. Lean amine pump
26. Lean amine cooler
27. Lean amine flow indicator
28. Rich amine pump
29. Refrigerant dryer
30. Activated alumina dryer
31. Nitrogen pressure governor
32. Nitrogen flowmeter

MATERIAL FLOW

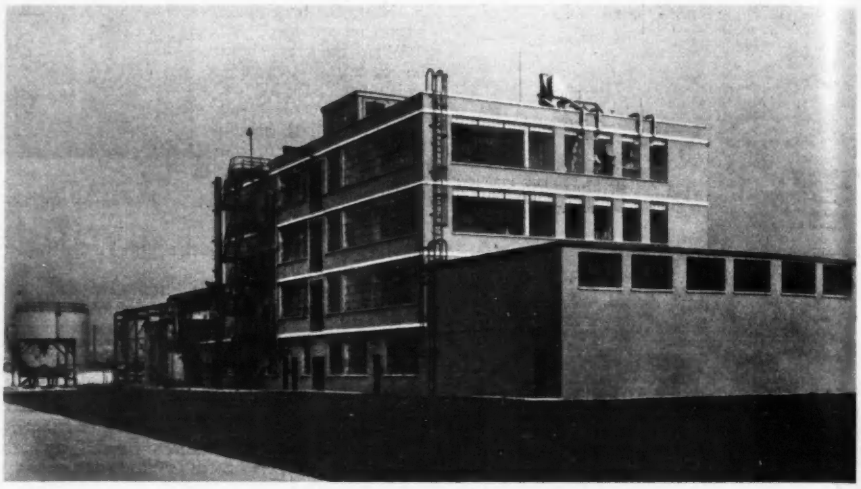
A. Raw gas
B. Air
C. Air-gas mixture
D. Burned gas
E. Nitrogen dewpoint ≦100 deg. Fah.
F. Nitrogen dewpoint +40 deg. Fah.
G. Nitrogen dewpoint ≦ −40 deg. Fah.
H. CO_2 Lean amine
J. CO_2 Rich amine
K. CO_2
L. Amine condensate return
M. Water of combustion

Fig. 3—Heat treatment plant. The absorption of carbon dioxide by water and ethanolamines

A General Purpose Polystyrene

As a result of an agreement between the Distillers Company, Ltd., and the Dow Chemical Company of America, a jointly owned company, Distrene, Ltd., has been formed to manufacture "Styron" in Great Britain. This material, which is a polystyrene and a product of the American company, is made by polymerising the styrene monomer which, in turn, is made from ethylene, a derivative from the cracking of crude oil in a refinery. To manufacture the new material a factory, the building of which was commenced in November of last year, has been completed in part of a 92-acre site, at Barry in South Wales, which already houses two other companies of the Distillers Company, Ltd. Our photograph illustrates the new factory, which has been completed in ten months and has been designed for an initial capacity of 6000 to 7000 tons per annum, with provision for additional production should demand increase. At present the company intends to make polystyrene moulding materials and toughened polystyrene which will be sold under the name of "Styron" in this country and under the name of "Distrene" abroad, the distribution being under the control of British Resin Products, Ltd. To mark the first production of "Styron" made in Great Britain a display of the wide variety of products and applications was held at the Mayfair Hotel, London, on October 17th. The display included examples of the material used in the chemical, electrical and catering industries, in aircraft, in the building trade, for domestic purposes, for packaging and the manufacture of refrigerators, and our photographs show two of the many items shown.

Two qualities of the material are available, namely, "Styron 666" and "Styron 475," and both are supplied to manufacturers in the form of externally lubricated uniform pellets and in a range of colours. The general mechanical and electrical properties of the new polystyrene moulding materials are indicated in the accompanying table. Both qualities are primarily processed by injection moulding, but may be formed by the extrusion and compression moulding techniques. "Styron 666" is a general-purpose polystyrene possessing good physical properties and moulding characteristics designed to meet the requirements of a wide range of applications. It is used for industrial and domestic mouldings ranging from refrigerator parts to electrical and radio equipment. "Styron 666" has a low specific gravity, low water absorption, good electrical characteristics, and is particularly suitable where ease of moulding allied with a consistent high level of physical properties are required. With regard to the electrical properties, the volume resistivity is high, so that the material is suitable for insulation purposes, but the power factor and dielectric constant are low, so that the material is a useful



The "Styron" factory of Distrene, Ltd., at Sully, Glamorgan

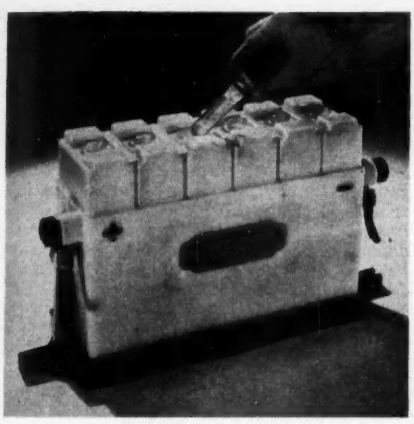
A television tube cover in "Styron 475"

Table of General, Mechanical and Electrical Properties of "Styron" Polystyrene

	Range or value		Method test
	"Styron 666"	"Styron 475"	
Bulk factor	1·8–1·9	1·8–1·9	Untapped, similar to B.S. 771
Specific gravity	1·04–1·06	1·04–1·06	By displacement
Tensile strength, lb/square inch	5000–6500	3000–4000	B.S. 1524
Elongation, per cent	1·5–2·5	10–30	Internal method
Charpy impact strength, ergs/cm squared	$1·5\times10^6$–$3·0\times10^6$	8×10^6–12×10^6	Internal method
Izod impact strength, ft-lb/in notch	0·25–0·5	1·0–1·8	B.S. 1493, Appendix "E," ½in × ½in notched test piece (compression)
Young's modulus, lb/in squared	$1·5\times10^6$–$5·0\times10^6$	$3·4\times10^6$–$4·0\times10^6$	Extension per load
Brinell hardness	20–23	13–16	10mm ball, 250kg load
Water absorption, mg	2·5	35	60 days' immersion at 20 deg. Cent., 2in diameter × ⅛in thick disc
Softening point, deg. Cent.	88–92	85	—
Specific heat, cal/deg. Cent./g	0·32	0·32	—
Electric strength at 20 deg. Cent.	550V/mil	550V/mil	B.S. 771
Power factor at 1 mc/s	0·0003–0·0005	0·0009–0·0012	B.S. 1493
Dielectric constant at 1 mc/s	2·45–2·55	2·45–2·55	B.S. 1493

dielectric material, but unsuitable for dielectric heating. The material has good light stability, and test pieces, aged indoors for three years, show no appreciable change in appearance or mechanical strength; however, prolonged outdoor exposure is not recommended since the material is not stable to ultra-violet light. Good resistance is offered to alkalis, salts, dilute mineral acids, lower alcohols and water, but not to higher alcohols, petrol, ketones, glacial acetic acid, oxidising acids, unsaturated hydrocarbons and essential oils, while in general it is soluble in aromatic and chlorinated hydrocarbons, esters, ethers and some terpenes.

Although it has a low water absorption rate it is essential to make sure that there is no surface moisture on the granules, or blisters may appear on the moulding. However, preheating is an aid to moulding operations and for this purpose air circulating ovens, and either infra-red or electric resistance heaters are satisfactory. Drying



An aircraft battery in "Styron 475"

times of forty-five to ninety minutes at 167 deg. to 176 deg. Fah. are recommended, while the injection moulding temperature range is 390 deg. to 570 deg. Fah., and the moulding pressure 10,000 lb to 18,000 lb per square inch, depending upon shape of section and rapidity of cycle. "Styron 666" can be machined, punched, buffed, drilled and also sawn, turned and milled, but care should be taken to ensure that the surface is kept below 140 deg. Fah. to prevent softening. Assemblies of moulded sections can be built up by joining the parts together by means of certain fast and medium drying adhesives and bodied adhesives. "Styron 666" may be formed by compression moulding, using temperatures ranging from 350 deg. to 375 deg. Fah., and is suitable for extrusion, its flow characteristics being similar to cellulosic thermoplastics.

"Styron 475" is a rigid thermoplastic belonging to the styrene-rubber group, and because of its extra toughness is suitable for manufacturing articles not formerly made from polystyrene materials. Many of the properties of this material are similar to ordinary polystyrene, but it is tougher, having higher impact strength and also considerably greater flexibility, as indicated by the stress-strain characteristics, which show high elongation at ultimate strength. The material is similar to "Styron 666" regarding light stability and ageing, has identical chemical properties, and similar remarks apply to the drying, preheating and injection moulding processes. For fabrication by compression moulding the temperature range is 325 deg. to 350 deg. Fah., and the pressure range 1000 lb to 5000 lb per square inch. The material can also be extruded to give a fine grained matt surface, while extruded sheet is suitable for moulding by the vacuum forming technique.

Battery of Aluminium Silos

A BATTERY of thirty-six 100-ton capacity aluminium grain silos, seen in our illustration, forms the latest extension to the grain storage facilities of Twyford Mill, Ltd., at Adderbury, near Banbury.

Extensive tests in recent years with many materials have shown that aluminium retains its clean appearance and hygienic qualities, does not harbour insect pests or promote mould growth. The aluminium silo is light in weight, excludes vermin, does not require painting or any other surface protection and can be erected or dismantled for re-erection elsewhere by unskilled labour.

Fabricated in Noral alloys by Frederick Braby and Co., Ltd., of Bristol, the silos at Adderbury are larger versions of the 20-ton Braby model and were designed and developed in conjunction with Northern Aluminium Company, Ltd. The body is cylindrical and is made from 16 and 18 S.W.G. standard 3in pitch curved corrugated sheeting, in six rings of six sheets to each ring. All holes are pre-pierced to ensure true cylindrical form and complete interchangeability. The base ring is in four sections, pre-pierced to marry with the sheets and to take ¾in diameter foundation bolts, while built into the second ring is a 9in diameter outlet chute, controlled by a gate valve.

The conical roof consists of twenty-four pre-pierced tapered 18 S.W.G. flat panels with interlocking fluted joints, surmounted by a welded cone cap, and is supported on twenty-four pressed brackets, arranged to prevent entry by birds. Two of the roof panels are in overlapping halves, the lower half of each being removable for filling and emptying purposes.

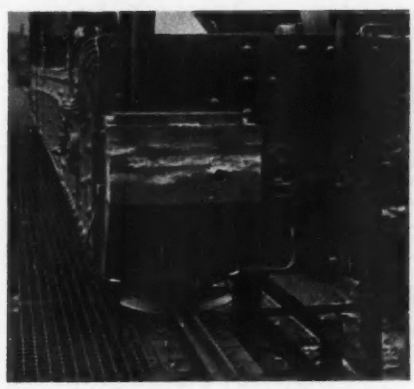
Mushroom-headed aluminium alloy screws and nuts, ⅜in diameter, are used as fastenings throughout.

The silo body is 20ft in diameter, 15ft high, the overall height being 21ft and weight 12 cwt.: the shape of the silo, in which the diameter exceeds the height, is the outcome of experience.

Battery of aluminium silos

Lubrication of Crane Rails

To avoid the heavy wear on wheel flanges and rails associated with travelling cranes, a lubricator on the De Limon system has been developed by Centralube, Ltd., Great Western Trading Estate, Park Royal Road, N.W.10. The principle of the device is that a film of oil is applied to that part of the head of the rail where the flanges bear, the tread, of course, being kept dry for traction. A pair of felt rollers hanging on penduli clasp



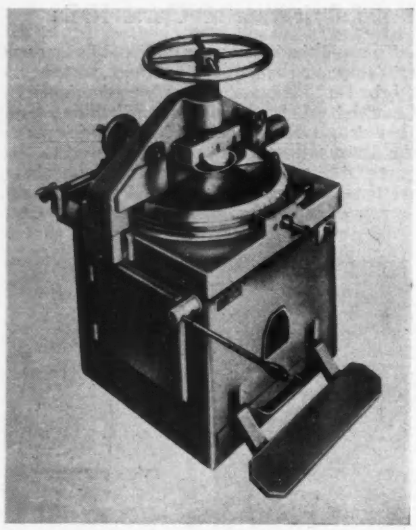
The two felt rollers of the lubricator are drawn together by a spring

the rail head, and, of course, roll as the crane moves; they are mounted on the travel frame, as shown in our illustration. The oil is metered by a "Multigreasor" with four outlets, driven from an eccentric on the travel shaft of the crane; ¼in o.d. pipes and flexible hoses lead it to the pivot on which the felt roller turns, and centrifugal force concentrates it at the periphery. Heavy machine oil is used and the consumption is only ¼ oz to ½ oz for each hour of operation. The makers observe that the benefits of repairs eliminated and out-of-service periods avoided are obtained only when this system of lubrication is applied to rails in good condition.

Cold Sawing Machines

AMONGST the sawing machines made by Hans Kaltenbach Maschinenfabrik and distributed in this country by F. J. Edwards, Ltd., 359–361, Euston Road, London, N.W.1, is the high-capacity circular saw illustrated below. The machine can be used with either 11¾in or 13¾in saws, giving respective capacities for work up to 2¾in and 3¾in. It is particularly suitable for bevel cutting of steel sections, angles, pipes and similar work in all metals.

In this machine the circular saw and its drive are completely enclosed in the cabinet base and



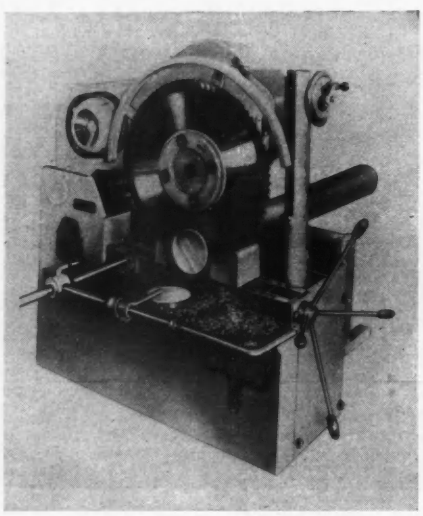
Circular sawing machine with a rotary table for cutting bevels and angles

the saw is fed up through a slot in the table in the cutting operation. The work is rigidly clamped on the table by an overhead vice and the angle of the cut is set by presetting of the rotating table assembly with reference to graduations round its periphery. The table can be turned through 180 deg. and stops are provided for the 90 deg. and the 45 deg. settings.

The position of the table relatively to the vice to suit the diameter of the work to be sawn is adjusted by a small handwheel at the rear of the machine. As mentioned above the saw is fed into the work from below and this operation is effected by foot pressure on a pedal bar. Irrespective of the pressure applied on the bar the actual speed at which the saw is fed into the work is controlled by the setting of a hydraulic cylinder within the cabinet.

A heavy-duty cold circular saw, made by the same firm and particularly intended for cutting off thin sections from bars, tubes, &c., is shown in our second illustration. This machine is made in three models covering saw blades from 20in to 50in diameter for work up to 15in diameter. In it the saw, complete with the drive, is mounted on a heavy arm pivoted on the column at the rear of the cabinet base.

The saw arm is fed down into the work by a hydraulic cylinder at speeds which are steplessly variable up to 20in per minute. The hydraulic system is so arranged that the feed pressure increases or decreases automatically in accordance with the thickness of the material being cut. A handwheel on the front of the saw arm is used to preset the height of the saw in relation to the stock. A roller support to facilitate the handling of heavy bars is provided at the rear of the self-centring vice and a gauge bar at the front of the vice.



Circular cold saw with adjustable hydraulic feed

Capstan Unit

THE self-contained electric capstan illustrated is marketed for a variety of applications, such as shunting trucks, dragging timber, beaching boats and bending pipes. Although it weighs only 5 cwt, it can exert a pull of 5000 lb, so that an anchorage is essential. However, the "Lo-Hed" unit is intended to be mounted above ground level, either, as shown, with a push-button

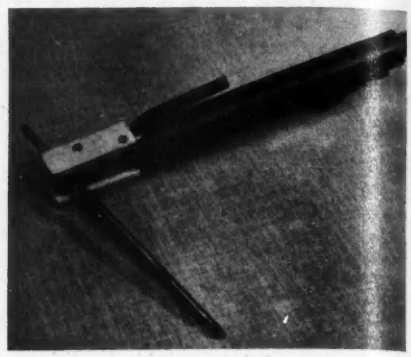
The capstan is seen here mounted on a concrete plinth for wagon shunting

control or with a pedal switch. The 5 h.p. electric motor is outside the capstan itself, and through two stages of reduction gearing, which is not irreversible, gives a line speed of 45ft per minute.

The capstan can either be supplied as a unit or completely installed by Taylor Stoker Company, Ltd., 189–191, Drummond Street, Euston, N.W.1.

Torch for Cutting and Gouging by Electric Arc

THE illustration at the top of column 3 shows a new tool, known as the "Arcair" torch, which has been developed by the Lincoln Electric Company, Ltd., Welwyn Garden City, Herts, for cutting, grooving and gouging metals at high speeds. With this torch the metal is melted by an electric arc and blown away by a continuous stream of compressed air. It operates with a supply of reverse polarity, direct current, from an ordinary welding machine and compressed air from a 90–100 lb per square inch works supply system. A special form of copper-coated carbon-graphite electrode is used with the torch and the electrodes are available in a variety of sizes ranging from $^{5}/_{32}$in to $\frac{1}{8}$in.



Metal cutting and gouging torch which uses an electric arc in conjunction with a stream of compressed air

Torches are available in two models, one for electrodes up to ¾in diameter for light duties and the other for heavier duties using the larger electrodes. Power and air supplies are connected through a concentric cable to the rear of the torch, which incorporates an air control valve. A self-aligning, rotating air jet in the electrode jaws permits adjustment of the electrode to any required angle to suit the work in hand.

When in use the torch is held with the electrode sloping back from the angle of travel and with the stream of air striking the metal being cut or gouged just behind the arc. During cutting the electrode is pushed continuously into the metal, almost touching it, and the air valve lever in the handle is depressed all the time the torch is in use.

Synthetic Laminate for Bearings

IN recent years the shipbuilding industry has tried out a number of new materials in its efforts to increase the reliability of ships' fittings. Of these materials the synthetic laminate "Tufnol," manufactured by Tufnol, Ltd., Perry Barr, Birmingham, has proved, it is claimed, specially suitable for bearings, as illustrated in our photograph. Some six years ago experiments were commenced using "Tufnol" for the rudder bearings on a number of ships ranging in size from a coaster to an ocean-going vessel of 20,000 tons deadweight. During this period about one hundred ships have been fitted and subsequent examination has indicated that the amount of wear is insufficient to allow the probable life of the fitting to be assessed. For example, it was found that after six years in service the clearance between the pintles and rudder bearings of a 1700 tons deadweight collier was found to be the same as when fitted. The material, which has been used for rolling mill bearings having water lubrication, is stated to resist corrosion, to be dimensionally stable, to be capable of being stored dry indefinitely, and to be available in radiused strips, or in tubular form. It is also available in sheets and strips and requires no special tools for machining.

Rudder bearing formed of radiused strips

Electric Furnace Melting Installation

A PHOTOGRAPH we reproduce on this page shows a recent addition to the electric furnace melting equipment at the works of K. and L. Steelfounders and Engineers, Ltd., at Letchworth. This 600kW, high-frequency furnace installation, built by Birlec, Ltd., is operated from a B.T.H. motor alternator set provided with a 1000 h.p. driving motor operating direct from the high-tension supply system of 11,000V. This is an unusually high voltage to use direct on a motor of this size without an intermediate step-down transformer, which, of course, means eliminating transformer losses. At the same time, the motor is of the synchronous type and will, therefore, not only operate at unity power factor, but also provide a small amount of reactive capacity to correct the power factor of the remainder of the works system.

The furnace equipment comprises two 25 cwt bodies, together with one 5 cwt body, any one of which can be connected to the motor alternator set through a three-way change-over switch arrangement. Special provision is made to ensure that the 5 cwt body cannot be loaded beyond 200kW, whilst the 25 cwt bodies can absorb the full available high-frequency energy. The melting rate is very high and it is stated that a full charge of 25 cwt can be melted in about 1 hour 20 minutes.

In order to simplify the operator's work these furnaces have been provided with automatic power factor correction, and the operator does not have to watch any instruments or carry out switching operations during the melting down period: the furnace always operates at maximum efficiency, a requirement that would otherwise need supervision. The equipment is also provided with a special form of power control, consisting of a water-cooled, high-frequency auto-transformer with remote push-button-operated contactors for controlling the voltage tappings. A graphic recorder is fitted to keep a continuous check on the earth leakage system, and any incipient faults in the furnace lining are detected immediately, so that the necessary steps for rectification can be taken.

The furnaces are fitted with hydraulic tilting equipment and to facilitate charging there is provided a hydraulic platform on which the charge can be wheeled to a furnace and raised to charging platform level. The firm states that the new equipment, on three shift workings, will enable a further 90 to 100 tons a week of liquid steel to be made. It will also widen the range of steel compositions which can be handled without disturbing the production programmes of the larger arc furnaces.

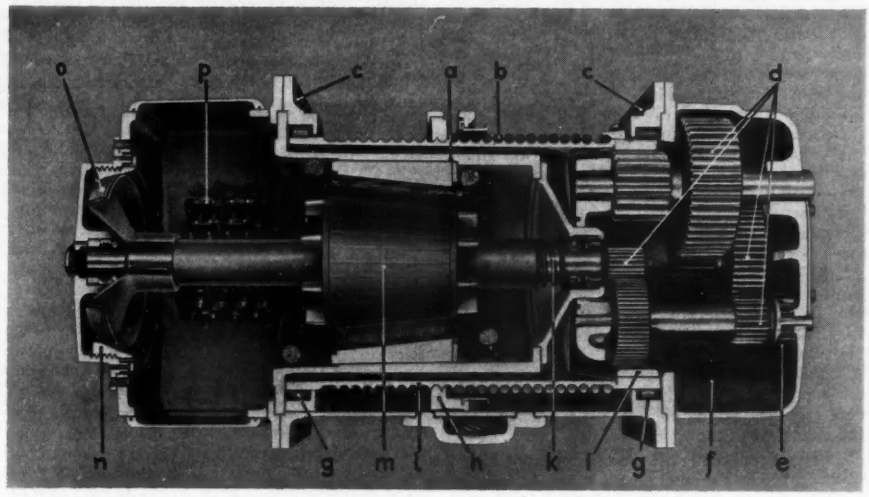
600kW high-frequency melting unit installation with liquid steel temperature measurement equipment incorporated in the control panel

Continental Engineering News

Electric Hoist

In the accompanying illustration we show the mechanism of an electrical hoist made by Demag-Zug, Wetter (Ruhr), German Federal Republic. The rope barrel moves on roller bearings inside the suspension flanges and is driven by the motor through a four-stage reduction gearbox. A rope retainer is provided which prevents the rope turns from coming loose on the barrel, and at the same time acts as a rope guide. Damage to the block through excess travel of the hook is prevented by a self-resetting limit switch, and control of the unit itself is exercised by means of a push-button switch. Maximum safety is stated to be obtained by having all the load-bearing parts made from steel. When arranged for travelling the block is run on the bottom flange of an I-girder or similar surface, smooth action being ensured by having the wheels fitted with ball bearings.

In the design here described, the brake mechanism engages or disengages automatically as the motor is switched off or on, in the following manner: the conical brake drum is mounted directly on the axially-slidable motor spindle and is pressed against its stationary housing by a helical spring. With the brake thus in the engaged position, the squirrel-cage rotor, also of conical shape, is displaced in relation to its normal running position. When the field is energised by switching on, the rotor is pulled into the stator against the spring pressure, thereby disengaging the brake. By virtue of the conical construction of the rotor, a strong axial force and finite displacement are obtained without great variation of the air gap. The maker is represented in this country by Aabacas Engineering Company, Ltd., Birkenhead.



a Motor casing with double bearings
b Steel wire rope
c Forged suspension flanges
d Gear wheels and pinions
e Anti-friction bearings of [double gear wheel
f Gearbox with grease bath
g Roller bearings of rope barrel
h Rope retainer
i Internal gear ring
k Rotor return and brake spring
l Rope barrel
m Conical sliding rotor
n Adjustable brake rim
o Electrically operated cone brake
p Automatic limit switch

Sectional view of hoist mechanism

Turbine-Driven Trawler

The trials took place on September 24th of the deep-sea trawler "Braunschweig," 652 tons gross, which was built for the Deutsche Heringsfischerei G.m.b.H., Cuxhaven, at the Seebeck yards of A.G. "Weser." The ship is stated to be the first of its kind to be equipped with a steam turbine as its main propulsion unit. The turbine, rated at 1000 h.p., drives the propeller through two-stage, 8000/1500/200 r.p.m. gearing, a 105kW, 380V, three-phase generator being coupled to the 1500 r.p.m. gear shaft. Three groups of fully automatically operated nozzles keep the speed constant at all loads, overloading to 1400 h.p. being permissible. An oil-fired water-tube boiler of 165 square metres heated surface supplies steam at 30 atmospheres gauge and 420 deg. Cent. superheater temperature; it is equipped with air preheater. The vessel has an Escher Wyss variable-pitch propeller, controllable from the bridge or from the engine room. The size of the refrigerated fish hold is 470 cubic metres. Designed for a speed of 13·5 knots, the ship carries 260 tons of fuel oil.

German Aircraft Industry

According to Press reports, a decision was recently taken by the German Defence Ministry regarding the rebuilding of aircraft production capacity in two groups, one south of the River Main and one north of it. The southern group, which is to commence manufacture soon, consists of the firms Messerschmidt, Dornier and Heinkel. At the Augsburg factory of Messerschmidt A.G., a jet trainer will be built, the development of which was carried out in Spain. The Dornier factory at Oberpfaffenhofen, is to build the light multi-purpose type "DO27," also developed in Spain. The northern group is to consist of the firms Blohm and Voss, Focke-Wulf and Henschel. A difficulty facing the industry is the almost total lack of test pilots.

Industrial and Labour Notes

Overseas Trade

At the end of last week, the final figures for the United Kingdom's overseas trade in September were published. Exports of United Kingdom goods were valued at £243,200,000, re-exports were valued at £10,600,000, and the value of imports was £304,400,000. The visible trade deficit was, therefore, £51,000,000, compared with £68,000,000 in August. In presenting these figures, the Board of Trade says that, in September, most categories of exports shared in the drop from the high level recorded in August, although shipments of coal and petroleum increased. In the first nine months of this year, the value of imports was £2884 million, which was 15 per cent higher than in the corresponding period of 1954, and exports of United Kingdom goods were valued at £2123 million, or nearly 6 per cent higher than in the comparable period last year. The visible trade deficit averaged £75,000,000 a month, compared with £47,000,000 a month in the first three quarters of last year. Nearly one-quarter of the increase in imports in the first nine months was attributable to higher prices, the increase in volume being about 11 per cent. The volume of exports rose by about the same proportion as their value, namely, 6 per cent; export prices showed little change until the later part of the nine-month period.

In some comments on the commodity pattern of trade, the Board of Trade says that, comparing United Kingdom exports between April and September with performance in the corresponding period of 1954, similar increases of about 7 per cent were recorded both for engineering products and for "other manufactures." Among the engineering exports, which were valued at nearly £90,000,000 a month between April and September, shipments in the machinery divisions were particularly good compared with a year earlier. Exports of non-electric machinery, which averaged about £37,000,000 a month in the April–September period, were 7 per cent higher than in the preceding year. In the same period of this year exports of electric machinery and apparatus averaged £15,000,000 a month, which was 8½ per cent above the level of last year. In the export of road vehicles and aircraft there was an increase of 4 per cent over a year ago, the monthly average from April to September exceeding £27,000,000. In the same period, exports of ships and boats averaged £4,000,000 a month, or nearly half as much again as in the preceding year. On the other hand, exports of railway vehicles were below the level achieved in the April–September period of 1954.

World Trade and Production

In its latest survey of this country's trade, the Board of Trade has made some observations on trends in world trade and production. It is pointed out that, both in Europe and in the U.S.A., industrial production continued to expand in the first half of this year. In the U.S.A., the survey continues, the expansion has continued steadily, and industrial production in the second quarter passed the peak reached before the recession began towards the end of 1953. In Europe, where in the middle of last year the rise in industrial production was accelerating, the rate of increase appears to have settled down in the first half of this year at a level about 10 per cent higher than a year earlier. Germany has led the expansion with an increase of 16 or 17 per cent in industrial production between the first half of 1954 and the same period this year.

The Board of Trade goes on to say that this growth in the economies of the industrial countries has been accompanied by an expansion in world trade. World exports, including United States "special category" exports of strategic goods were 9 per cent higher in value in the first quarter of this year than in the corresponding period of 1954. The rise in exports from Europe, North America and Japan, it is stated, is reflected in the increase in world trade in manufactured goods. In the first half of 1954 exports of manufactures from those areas were 7 per cent higher than a year earlier; by the second half of the year the rate of increase had risen to 8 per cent, and in the first half of this year it rose to 13 per cent. The United Kingdom's share of exports of manufactured goods in the first half of this year was just under 20 per cent, even after making some allowance for the effect of the dock strike, compared with 21 per cent in the first half of 1954. Canada's share of the total has also declined since the first half of last year, while the shares of the U.S.A. and Germany have both risen.

Coal

This country's coal position has again been assessed in *Bulletin for Industry*, a publication which is prepared monthly by the information division of the Treasury. There it is noted that in the first nine months of this year the total coal production was 3,250,000 tons lower than in the corresponding period of last year. That, the *Bulletin* says, must be considered as equivalent to an annual loss of around 4,250,000 tons, which represents more than a whole year's coal consumption by the engineering and metal trades (apart from the iron and steel industry).

As is now so well known, the declining output and rising consumption have necessitated a large coal import programme. Up to the end of September, coal imports this year totalled over 8,500,000 tons (equivalent to an annual rate of nearly 12,000,000 tons), or an increase of more than 7,000,000 tons over the first nine months of 1954. Nearly half the imported coal in the first nine months of this year came from the U.S.A. providing one of the principal reasons for the sharp increase in dollar expenditure, and Western Europe supplied most of the rest. The cost of coal imports in the first eight months of this year is put at £48,500,000. Since last March, the *Bulletin* adds, coal imports have been arriving at a rate of 250,000 tons a week. Not much more can be obtained from Europe, shipping capacity for bulk cargoes from North America is limited, and port and transport facilities in this country are fully employed.

The *Bulletin* goes on to say that the two biggest causes of the lower output of deep-mined coal have been disputes and smaller output per man-shift. Disputes caused a loss of about 1,000,000 working days in the first nine months of this year, at a cost of 2,300,000 tons of coal. Output per manshift overall, in the first thirty-eight weeks of the year was, on average, 1 per cent down compared with a year earlier, and this has cost something like 1,500,000 tons. Then, too, manpower has declined. On September 24th, the number on colliery books was 700,000, or 5000 less than at the beginning of the year. The average manpower figure in the first nine months of this year was 2400 below that of the comparable period of last year and, so far, has cost the country about 500,000 tons of coal. Thus, it is claimed, disputes and lower output per manshift and reduced manpower have together been responsible for most of this year's drop in coal output.

In contrast to this year's drop in coal production, there has been an increase in inland consumption. In the first thirty-eight weeks, the increase amounted to 500,000 tons and would, no doubt, have been more than that but for the warm summer and the cuts in consumption on account of the railway strike. The *Bulletin* notes that in the first quarter of the year there was an increase of 1,700,000 tons, or 2·9 per cent, over a year earlier; in the next two months the increase was quite small, and in June, July and August there was a drop in consumption of 1,500,000 tons. In September, coal consumption returned to last year's figure. It must be remembered that the last quarter of 1954 was unusually mild, so that it must be expected that, for the remainder of this year, with the increasing rate of industrial activity, consumption will be higher than in the comparable period of last year. In the first thirty-eight weeks of this year the amount taken up in exports and bunkers was 2,000,000 tons less than a year earlier. The two main overseas markets, Eire and Denmark, have so far received about the same amount of coal as last year, but other countries, notably the Argentine, Italy and Spain, have had reduced supplies. Summing up the situation, the *Bulletin* comments that heavy imports of coal and a cut in exports, combined with the warm summer, have made possible the rebuilding of stocks to a fairly satisfactory figure. But, it is added, "there is little scope for further augmenting our supplies from overseas, and high industrial demand would, even in a normal winter, stretch our resources to the limit."

British Productivity Council's Report

The British Productivity Council, it will be recalled, was formed in November, 1952, to continue much of the work done by the United Kingdom section of the Anglo-American Council on Productivity. It is composed of representatives of employers' federations, trade unions and the nationalised industries, the one aim being to assist the increase of productive efficiency in industry as a whole. The Council's programme —including the formation of local productivity committees and the "circuit scheme" for inter-factory visits—was announced early in 1953. This week, the Council has published its second progress report, which surveys its activities in the year ended March last.

The report records that the number of local productivity committees and associations has increased to 102, and that the circuit scheme for inter-factory visitation continues to occupy a leading place in the programmes of these committees and associations. Furthermore, for some time the council has had a "work study unit" for lectures and practical demonstrations. In all parts of the country, the report says, the demand for the services of this unit has far exceeded its resources, and the unit is now fully booked until the summer of next year. The council believes work study to be a technique that offers the best prospects of increased productivity "with little or no capital expenditure, and of universal application." The object of the unit is to stimulate a wider appreciation of the value of work study, and particular attention is given to the human implications. The report says that one of the most striking manifestations of the growing enthusiasm for work study is the demand for instruction in the technique. At the council's suggestion three further ten-week courses have recently been started by the Ministry of Education in Glasgow, Leicester and Loughborough. A number of shorter appreciation courses have also been established in other technical colleges.

Overseas Publicity for British Industry

The Federation of British Industries has published a booklet, entitled *Telling Industry's Story Overseas*, which is a guide to the channels available for distributing industrial information overseas. The booklet has three parts, the first of which describes the "final outlets" for industrial information (as distinct from advertising), such as newspapers and journals, broadcasting services, locally shown films, and talks overseas by visiting British business men. The second part deals with the channels through which information may be fed to these outlets, and there is then a final chapter offering advice on the way in which firms can make the best use of these channels. In the introduction to this booklet it is emphasised that the reputation of British industry depends on such factors as price, quality and deliveries. But, it is added, it is not enough to make good products, "their excellence must also be made widely known." Full information overseas about a firm's products not only helps to arouse interest in those products, but helps also to build up the prestige of British industry as a whole.

The booklet, price 3s. 6d., is available from the Federation of British Industries, 21, Tothill Street, London, S.W.1.

Work of the U.S. Atomic Energy Commission

BY OUR AMERICAN EDITOR

No. II—(*Concluded from page* 601, *October* 21*st*)

The eighteenth bi-annual report to Congress of the U.S. Atomic Energy Commission (A.E.C.) emphasises that the rapid advance of the "Atoms-for-Peace" programme stands out in the record of atomic energy developments of the past six months. In this period twenty-seven nations entered into agreements for co-operation with the United States in developing the civil uses of atomic energy. To supply the fuel that would eventually be required for research reactors under these agreements, the President authorised adding 100 *kg of uranium* 235 *to the original* 100 *kg set aside in late* 1954 *for this programme. He also advocated the construction of a nuclear-powered merchant ship for demonstration cruises and proffered financial aid to other nations in the construction of research reactors, and training and technological aid in the development of power reactors by friendly nations.*

Physical Research

SINCE the beginning of the atomic energy project eight elements heavier than uranium have been created artificially. Recently scientists working under Dr. Glenn T. Seaborg, at the University of California Radiation Laboratory, identified element 101. The newly discovered element contains 101 protons and 155 neutrons in its nucleus. To form the new atomic species, element 99 of mass number 253 was bombarded with 41MeV helium ions from a cyclotron. A neutron released in the ensuing nuclear reaction yielded the observed isotope of element 101. Seventeen atoms of the isotope were identified. They are radioactive, with a half-life of one-half hour. It was proposed by the discoverers to name the element Mendelevium (Mv) in honour of the Russian scientist Dimitri Mendeleev. The identified isotope would be represented as 101Mv 256.

Thorium metal is the starting material from which uranium 233, a fissionable isotope of uranium, is made. Reactor cores containing uranium 235 can be surrounded with a blanket of thorium metal, which absorbs the stray neutrons, leaving the core and with the added neutrons becomes uranium 233. Thorium is now produced by batch processes requiring expensive reagents. At the Oak Ridge National Laboratory a promising semi-continuous process for thorium production has now been developed, and appreciable savings are expected from the process, which uses inexpensive reagents.

Cloud chambers and photographic emulsions have provided conventional methods for studying the mass, energy, and reactions of high energy nuclear particles. More recently, a technique was developed by Donald A. Glaser of the University of Michigan that offers significant advantages over cloud chambers and emulsions in nuclear research. Glaser succeeded in photographing bubbles of vapour formed along the tracks of cosmic ray particles passing through superheated ether. His success encouraged scientists working at other laboratories to explore the advantages of bubble chambers, especially for studying reactions of mesons and protons. Through the use of a special liquid hydrogen bubble chamber, meson tracks were observed during operation of the bevatron at the University of California Radiation Laboratory. The density of the liquid hydrogen in the chamber is equivalent to that which would be obtained if an ordinary cloud chamber were operated at about 700 atmospheres. Consequently, the large amount of material in the path of the speeding mesons permits observation of rare particle interactions. Also, the target nucleus can be positively identified, since the liquid hydrogen nucleus consists solely of protons.

Research in University Laboratories

The physical research programme of the A.E.C. is the source of many of the new ideas contributing to progress in atomic energy. Here, too, is where the atomic scientists of the future first become interested in the Commission's problems and begin their work in the programme. Naturally, the universities play an essential part because of their traditional responsibilities for advancing fundamental knowledge and teaching students. Fortunately, the areas of science where advancement most benefits the atomic energy programme are also of great interest to the academic scientists. For this reason it is possible to enlist the assistance of professors and their students in university departments of physics, chemistry, and metallurgy for research which advances atomic technology and, at the same time, strengthens the universities in their efforts to keep pace with the rapidly increasing demand for qualified scientists. The record shows that the great majority of those who are now entering careers in the laboratories where atomic weapons or atomic power plants are being developed began as assistants on research projects conducted for the A.E.C. by the universities.

The Atomic Energy Act of 1954, like that of 1946, directs the Commission to conduct research and development in support of the atomic energy programme, both in its own facilities and through contracts or other arrangements with independent institutions. In response to this directive, and in recognition of the unique service the educational institutions can render the programme, the Commission is contracting with ninety different universities, colleges and research institutions for fundamental research in the physical sciences. Universities have traditionally supported research to expand the frontiers of human knowledge, and in those areas bearing on atomic energy they have a common interest with the Commission. Normally contracts between the Commission and a university for basic scientific research are based upon proposals made by the university scientists, and the results of the research are generally made available to the scientific community through publication in the open literature. The Commission believes that giving free latitude to individual initiative is the surest way to ensure that significant new ideas are conceived and rapidly developed.

An arrangement which the Commission has adopted for assisting research in universities and colleges is the lump-sum joint participation contract. These contracts may be used when the annual cost to the A.E.C. is less than 100,000 dollars, when the cost can be estimated with reasonable accuracy in advance, and when the contractor and the A.E.C. both contribute to the costs. In consideration for the work undertaken and the submission of a satisfactory report, the A.E.C. pays a lump-sum based upon a part of the estimated total cost. These contracts involve a minimum of supervision and auditing. Projects requiring the A.E.C. to pay substantially all of the costs, or those for which the costs cannot be estimated with reasonable accuracy, are financed by contracts under which the A.E.C. controls expenditures and audits the accounts. Irrespective of contract, the payments assist the institution to meet the expenses of the project, which usually include summer salaries of the investigators, supplies and equipment, and part-time employment of graduate students who partake in the work and often use the results as material for a dissertation.

Since the inception of the Commission's university research programme in 1948, these institutions have made many contributions to the advancement of the atomic energy programme. Investigations in which they have had a leading part are those designed to develop a better fundamental understanding of the nuclear processes involved in the release and use of atomic energy. They have also made substantial contributions to knowledge in chemistry and metallurgy basic to the development of new processes for the manufacture and use of nuclear and other special materials. In carrying out such investigations for the Commission the educational institutions are also substantially strengthened for their primary task of training the manpower which flows in an increasing, but still insufficient stream, from university classrooms and laboratories into the plants and other establishments where the end products of the programme are being developed or manufactured.

Most of the university laboratories engaged in nuclear research for the Commission use a

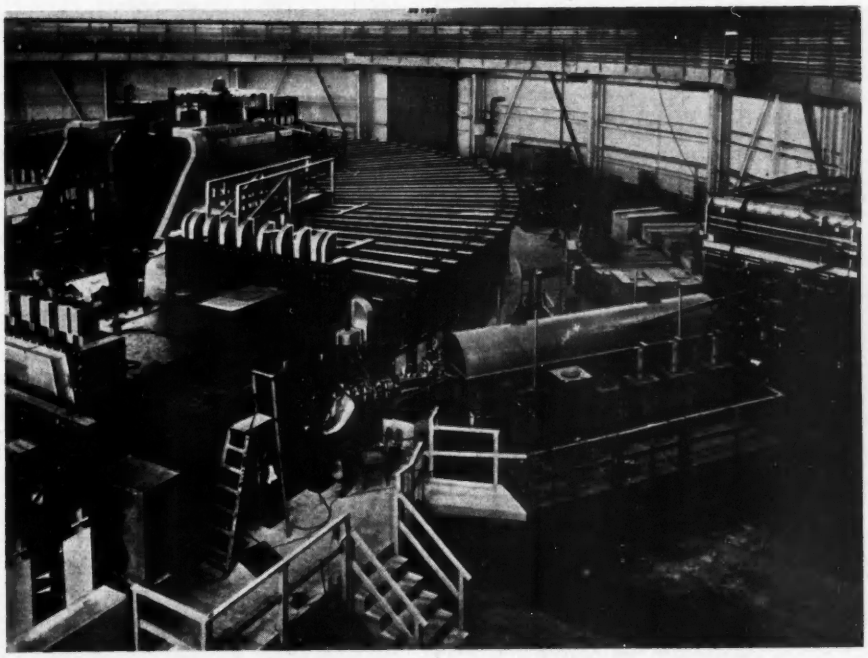


Fig. 4—Bevatron particle accelerator at the University of California Radiation Laboratory, Berkeley

particle accelerator (one of which is shown in Fig. 4) to supply high velocity particles. Reactors are less common, although several universities are now acquiring them and one is already in operation at the North Carolina State College. The accompanying table lists the educational institutions where particle accelerators are being used for Commission research. This table also includes institutions where projects in nuclear physics are jointly supported by the A.E.C. and the U.S. Navy. As shown in the table, several kinds of accelerators are in use—cyclotrons, electrostatic generators, synchrotrons for both electrons and protons, betatrons, and linear accelerators, and currently there is a total of sixty-two accelerators at thirty-three universities.

TABLE—*Particle Accelerators used for A.E.C. Research by American Universities*

Institution	Particle	Energy (MeV)	Year of completion	Type of research
Synchrotrons :				
California Institute of Technology	Electron	1000	1953	Meson production
University of California Radiation Laboratory	Electron	335	1948	Nuclear structure
	Proton	6100	1953	Meson production and scattering, neutron and proton interactions
Cornell University	Electron	1500	1955	Meson physics
Iowa State College	Electron	80	1951	Nuclear structure
Massachusetts Institute of Technology	Electron	330	1950	Nuclear structure
Michigan, University of	Electron	300	1953	Electron scattering and nuclear structure
Purdue University	Electron	300	1953	Nuclear forces
Synchro-Cyclotrons (accelerator diameter shown in parentheses) :				
University of California Radiation Laboratory (184in)	Deuteron	195	1946	Meson production and scattering, high energy nuclear reactions
	Proton	350		
	Alpha	390		
Carnegie Institute of Technology (142in)	Proton	440	1952	Meson production and scattering, high energy nuclear reactions
Chicago, University of (170in)	Proton	400	1951	Meson production and scattering, high energy nuclear reactions
Columbia University (170in)	Proton	400	1950	Meson production and scattering, high energy nuclear reactions, high resolution slow neutron spectroscopy
Rochester, University of	Proton	240	1948	Meson production and scattering, high energy nuclear reactions, high resolution slow neutron spectroscopy
Cyclotrons (accelerator diameter shown in parentheses) :				
University of California (Los Angeles) (37in)	Proton	18	1934	Nuclear reactions, proton group studies
University of California Radiation Laboratory (60in)	Proton	9	1939	Heavy ion acceleration, production of radioisotopes, nuclear reactions
	Deuteron	18		
	Alpha	36		
Columbia University (36in)	Proton	4	1939	Slow neutron spectroscopy
	Deuteron	8		
Harvard University (92in)	Proton	125	1949	Nuclear reactions and nucleon scattering
Illinois, University of (41in)	Deuteron	10	1940	Nuclear reactions, scattering
Indiana University (45in)	Deuteron	22	1941	Nuclear reactions, scattering
Michigan, University of (42in)	Deuteron	10	1950	Fast neutron spectroscopy
	Proton	20		
Ohio State University (42in)	Proton	5–7	1951	Nuclear reactions, nuclear scattering
	Deuteron	10		
	Alpha	20		
Pittsburgh, University of (47in)	Deuteron	16	1940	Nuclear reactions, nuclear scattering
Princeton University (35in)	Proton	18	1951	Precision nuclear reactions and scattering
Purdue University (37in)	Deuteron	11	1936	Nuclear reactions and structure
	Alpha	21		
Rochester, University of (27in)	Proton	7	1936	Nuclear structure, nuclear scattering
Washington, University of (60in)	Deuteron	20	1951	Excitation functions and alpha particle scattering
	Alpha	40		
Yale University (28in)	Proton	4	1940	Nuclear structure
Betatrons :				
Case Institute of Technology	Electron	30	1949	Nuclear reactions, electron scattering
Chicago, University of	Electron	100	1950	Nuclear reactions
Illinois, University of	Electron	22	1949	Nuclear reactions
	Electron	80	1949	Nuclear reactions
	Electron	300	1950	Meson production, electron scattering
Pennsylvania, University of	Electron	22	1949	Nuclear reactions
Linear accelerators :				
University of California Radiation Laboratory	Proton	32	1947	Nuclear spectroscopy, nuclear scattering
	Heavy ion	10/nucleon	1957	Under construction (nuclear chemistry)
Massachusetts Institute of Technology	Electron	16	1950	Nuclear reactions
Minnesota, University of	Proton	40	1952	Scattering, nuclear reactions
Purdue University	Electron	10	1952	Nuclear reactions, low energy electron scattering
Stanford University	Electron	70	1955	Under construction (accelerator development)
	Electron	680	1956	Under construction—now in partial operation (meson production, electron scattering)
Yale University	Heavy ion	10/nucleon	1957	Under construction (nuclear physics)
	Electron	—	1955	Slow neutron spectroscopy
Electrostatic generators :				
Bartol Research Foundation	Proton	2	1951	Fast neutron scattering
California Institute of Technology	Proton	1·5	1946	Nuclear spectroscopy
	Proton	3	1948	Nuclear spectroscopy
	Proton	4·5	1950	Nuclear spectroscopy
Columbia University	Proton	5·5	1955	Fast neutron and nuclear, spectroscopy
Duke University	Proton	4	1951	Fast neutron and nuclear, spectroscopy
Iowa, State University of	Proton	4	1950	Nuclear spectroscopy
	Deuteron	4		
Johns Hopkins University	Proton	3	1953	Nuclear spectroscopy, fast neutron reactions
Massachusetts Institute of Technology	Proton	1	1938	Nuclear spectroscopy
	Proton	5	1947	Nuclear spectroscopy
	Proton	8	1952	Nuclear spectroscopy
Minnesota, University of	Proton	3·75	1940	Nuclear spectroscopy
	Deuteron	3·75		
Notre Dame, University of	Electron	2	1940	Electron scattering
Ohio State University	Proton	2	1950	Nuclear spectroscopy
Pennsylvania, University of	Proton	1·5	1951	Nuclear spectroscopy
Rice Institute	Proton	2	1946	Nuclear spectroscopy, fast neutron scattering
	Proton	6	1952	Nuclear spectroscopy, fast neutron scattering
Texas, University of	Proton	4	1952	Nuclear spectroscopy, fast neutron interactions
Virginia, University of	Proton	1	1955	Nuclear spectroscopy, fast neutron interactions
Wisconsin, University of	Proton	4·5	1939	Nuclear spectroscopy, fast neutron scattering

METALLURGICAL RESEARCH BY UNIVERSITIES

More than seventy of the 101 recorded elements are metals, but only a relatively few of these are now developed as materials of industry. The discovery of additional useful materials was speeded up by the exacting requirements of the atomic energy programme, which makes it necessary to examine carefully all of the elements in the periodic table to determine their nuclear, chemical and physical properties. Some metals produced commercially prove satisfactory for use in reactors, accelerators and weapons, but this is the exception. More commonly, the treatment, processing and mixing of metals as alloys are required to provide a suitable material. Ceramics have proved useful for some high-temperature applications where conventional metals and alloys fail. The A.E.C. has about fifty university contracts for research of long-range interest in metallurgy. They deal with : (1) the production, treatment and properties of materials of interest to the A.E.C.—such as uranium, thorium, zirconium, &c. ; (2) the structural nature of solids, including alloys, and (3) the effects of various kinds of radiation on materials.

One of the characteristics of solid metals is the arrangement of their atoms in a periodic array of crystal lattice. In the very simplest case, the lattice is made up of cubical cells stacked face to face. Atoms are situated at each of the eight corners of every cube. Some metals are built as variations of this simple structure, whereby an additional atom is situated at the centre of the cube (body centred cubic) or further atoms occupy the cube faces (face-centred cubic). Other metals have still more complicated structures. The distance between atoms in a unit cell varies with the metal, but is of the order of one-hundred-millionth of an inch. Single crystals in which the lattice structure is continuous throughout can be produced in pencil size, or larger, but the usual metal is an aggregate of many small crystals or grains, randomly oriented. In these, the adhesive forces between grains are of special interest in determining the strength of the metal. Bi-crystal specimens are frequently used for research purposes, since they consist of two single crystals separated by a single grain boundary. Crystal dislocations are regions of misfit in which one section of the crystal contains an extra plane of atoms relative to the adjacent section. Regions of misfit thus give rise to an alignment of lattice defects known as dislocation pipes or channels. For example, these defects can occur when one portion of a crystal is caused to slide or slip over the remaining portion. Studies of crystal structure and its influence on the properties of solids are proceeding at the University of Virginia, New York University, Massachusetts Institute of Technology, and the State University of Iowa.

The phenomena of self-diffusion and inter-diffusion are of extensive scientific and technological importance, since atom movements are involved in practically all metallurgical reactions and processes. For example, diffusion plays an important part in the homogenisation of alloys, the heat-treatment and tempering of metals and alloys, the sintering or heat-bonding of metal powders, the coating and cladding of metals to improve or protect the surface, and in a host of other operations. The use and understanding of the diffusion process is essential in the fabrication and cladding of reactor fuel elements, in the processing of the irradiated elements for fuel recovery, and in other problems of vital interest to the A.E.C. University laboratories that have assumed an active part in this programme, under A.E.C. contracts, are the University of Illinois, Carnegie Institute of Technology, and Rensselaer Polytechnic Institute.

Experimental and theoretical studies on the basic mechanisms of diffusion in metallic systems are being made at the University of Illinois, where a binary alloy system is under study. Particular attention is being devoted to precise radioactive tracer measurements of the migration of solvent and solute atoms in these alloys. With solid solutions of metals in silver, the new work showed that the solute atoms diffuse faster than the silver atoms in those cases where the former are heavier than silver, i.e. lie to the right of silver in the periodic table of the elements (e.g. cadmium, indium, tin, and antimony). On the

other hand, the metals diffuse slower when they are lighter than silver. The effect depends upon the difference in atomic number between the solvent and the solute. The investigators at the University of Illinois developed a theory of the dependence of the diffusion mechanism upon atomic number, giving a good explanation of many of the experimental facts.

At the Carnegie Institute of Technology the problem of grain boundary diffusion in solid solutions is being studied. In this work the diffusion of silver along grain boundaries of columnar bi-crystals of copper was investigated by the radioactive tracer technique and shown to be much greater than atom movements within the body of the crystals. In an extension of this work it was shown that diffusion along grain boundaries depended to a great extent on the direction of the movement. In a parallel study on self-diffusion along grain boundaries in bi-crystals of the body-centred cubic lattice (i.e. iron containing about 3 per cent silicon), it was shown that there is a good correlation between the density of dislocations in grain boundaries and the depth of diffusion penetration. This aspect of the programme is continuing to clarify the part of atomic size in grain boundary diffusion and the diffusion behaviour along grain boundaries made out of various kinds and combinations of dislocations.

It is well known that many metal crystals exhibit different diffusion rates in the various lattice directions. This problem of anisotropy of diffusion is being investigated at the Rensselaer Polytechnic Institute. Measurements of the diffusion coefficients and energies required for diffusion in different lattice directions in zinc, cadmium and thallium have been completed. Similar studies on antimony, arsenic and bismuth —members of a different crystal system—are in progress. Moreover, it is intended to study the anisotropy of diffusion in iridium and uranium. A knowledge of the diffusion rates in uranium in the different lattice directions is considered to be of vital importance in understanding many of its peculiar characteristics.

Sintering

The sintering process of bonding metal or other powders by heating below the melting temperature to form a strong cohesive body is often employed in making special materials required in the atomic energy programme. It has been shown that atoms move within metals, especially at higher temperatures, and that bonding of metals can result from this process. Thus, diffusion is generally acknowledged to take place during the sintering process. Sintering in certain cases is believed to be partly due to the flow of the powdered material under the processing conditions—a phenomenon known as plastic flow. New cohesive bonds are thus formed both by diffusion and by plastic flow. Other mechanisms are also thought to contribute to the bonding of powders. To clarify this mechanism of sintering in metals and ceramic powders experimental and theoretical studies financed by the Commission are proceeding at various laboratories, including work at the Massachusetts Institute of Technology and the University of Utah.

At M.I.T., sintering studies were made for sodium chloride, glass, copper, aluminium oxide, zirconium dioxide, sodium fluoride, and calcium fluoride. It was shown that sodium chloride, glass and copper sinter by a distinctly different mechanism. Investigations are planned for systems which have a limited quantity of material present in the liquid state, and surface energies will also be studied. At the University of Utah research is being done on the sintering characteristics of alumina (Al_2O_3), with special attention to recrystallisation and the influence of impurities. Since the sintering process is often accompanied by an increase in the grain size of the material, relationships will be sought that link recrystallisation, grain growth and impurities. The Utah investigators have already found that impurities can increase or decrease the temperature at which recrystallisation will occur and that the observed effect depends upon the particular impurity present. Measurements of plastic deformation under load are also being made in order to determine the effect of crystal structure on this property of materials.

Biology and Medicine

The biology and medicine programme of the Commission includes research relating to the establishment of control measures against harmful exposure to radiation for the protection of atomic energy workers and the public. Laboratory and field investigations continued in the past six months to be projected toward studies of the effects of radiation on living things, understanding the mechanisms by which these effects are produced, and developing controls for and methods of protection against damaging effects. Various safeguards were in effect during Operation " Teapot " to hold to a minimum the exposure of the public to fall-out radioactivity. The Commission also maintained an extensive monitoring system to detect and measure levels of radioactivity near the test site and also at points throughout the United States. In general, the radiological safeguards and the monitoring system were similar to those for previous Nevada test series, but past experience made it possible to improve controls and procedures in several respects. As a result fall-out outside the controlled area was less than that resulting from the preceding Nevada test series in the spring of 1953. Off-site levels of radioactivity were well below those which would impair the health of human beings or animals or cause damage to crops.

Improved weather prediction techniques and methods of forecasting fall-out intensity and location were utilised in the latest test series. For the first time, towers as high as 500ft were built, and their use helped to keep fall-out to a minimum. As in the past, all factors relating to health and safety were carefully considered by an advisory panel before the detonation of each device. The system of radiological monitoring around the test site was strengthened by a reorganisation of procedures and the addition of two additional monitoring programmes. The area within 150 miles of the test site was divided into twelve zones, each of which was staffed by a joint A.E.C. Public Health Service team. The personnel lived in communities within their zones during the test series, and acted both as monitors and as liaison between the residents and the test organisation. There were also six mobile teams which moved to areas where additional monitoring was desired. In addition to the monitoring teams, about thirty automatic recording instruments and the same number of telemetering units were in operation in localities within about 350 miles of the test site. The telemetering units were part of a unique system which made it possible for an operator at a control point to place a long-distance telephone call to each unit, and to receive signals which could be translated into radiation readings in a few seconds. As in the past, aerial surveys were conducted to provide for monitoring over large areas in a relatively short time.

The monitoring systems described above were used to obtain information on radiation levels within a few hundred miles of the test site, where more fall-out would be expected. To provide a continuous record of the lower level fall-out in more distant areas, samples were collected at eighty-nine U.S. Weather Bureau Stations across the country as part of the Commission's National Monitoring System. This system has operated during previous Nevada series, and is maintained on a partial basis between testing periods. Weather Bureau personnel at the stations co-operate with the Commission by serving as fall-out collection agents. A 1ft square gummed film, spread on a 3ft high stand, provides a simple but excellent device for catching and retaining fall-out particles. The films are changed each day. After being exposed, the film is mailed to the Health and Safety Laboratory at the Commission's New York Operations Office, where it is reduced to ash in a vacuum furnace and the radioactivity in the ashes is measured. Through the use of production line techniques, it is possible for the laboratory to count 400 to 600 such samples per day.

In the area surrounding the test site, monitors made measurements of external gamma radiation, of airborne radioactivity, and of radioactivity in water. The highest measurement of external gamma radiation experienced in a populated area off the test site during Operation " Teapot " was 2·9 röntgens, expressed in units of " effective biological dose," which represents the best estimate of radiation dosage in terms of its biological effects. In calculating the effective biological dose, account is taken of reduction in exposure as a result of weathering and shielding by walls and buildings. The operational guide established by the test organisation in terms of the effective biological dosage for exposure of the public to radiation was 3·9 röntgens in any one year. This limit was not exceeded at any community nor at any place where people were living.

Although past experience indicated that the concentration of radioactive fall-out material in the air was of secondary importance to the external gamma radiation, the air monitoring programme was continued. The highest concentration of radioactivity in the air following any one detonation was at Ely, Nevada. This amounted to about 6/100 of a micro-curie per cubic metre averaged over the twenty-eight hours that the material was present in significant quantities. The highest concentrations in air, averaged for the entire series, occurred at Ely, Nevada and Alamo, Nevada, where the total additional radiation doses to the lungs from inhaling fall-out material were estimated to be about equivalent to that expected from breathing air containing normal amounts of naturally radioactive materials, for a period of several days.

Anglo-American Agreement on Rocket Propulsion Systems

A mutual technical assistance agreement has been reached by North American Aviation, Incorporated, of Los Angeles, and Rolls-Royce, Ltd., of Derby. Under the agreement, North American will license Rolls-Royce to manufacture rocket propulsion systems designed and developed by the American firm, and both companies will exchange technical information relating to development, design and production in these fields. The agreement covers a ten-year period. The agreement was entered into between the two companies with the approval of the United States and British Governments, and is considered to fall within the Wilson-Sandys collaboration agreement on guided missiles, which was concluded between the United Kingdom and the United States last year.

North American Aviation has been conducting a broad research and development programme in the field of rocket propulsion systems and long-range guided missiles since 1945. In addition to work on its own " SM–64 Navaho " inter-continental surface-to-surface guided missile, the firm also is supplying propulsion systems for other missile programmes in this country. Relatively small-size rocket engines capable of developing for a short period large amounts of jet horsepower have been successfully tested at the company's Propulsion Field Laboratory, which is situated 35 miles north of Los Angeles. In 1953, North American Aviation first announced that it had received production orders for large rocket propulsion systems. At that time it also announced that it had already delivered large rocket engines for various uses and that it had received other contracts for small ordnance rockets. It was also disclosed in 1953 that the propulsion section of the firm had designed and built for the U.S. Air Force a 50,000 lb thrust liquid propellant engine capable of accelerating a test sled to more than 1500 miles per hour in 4·5 seconds along a 5500ft track. This engine was installed and used on a sled produced by the research laboratories division of the Cook Electric Company for the Wright Air Development Centre of the U.S. Air Force. To meet the continuing needs of its expanded rocket propulsion activities, the company is now constructing a large propulsion development centre in the San Fernando Valley of California. Scheduled for completion this autumn, this new facility will become the headquarters for the company's research, development and manufacture of rocket propulsion systems.

Personal and Business

Appointments

MR. A. G. BREARLEY has been appointed technical director of Catton and Co., Ltd., Leeds.

MR. A. S. C. CHATTEY, managing director of A.C.V. Sales, Ltd., has been appointed to the board of A.E.C., Ltd.

MR. A. M. A. MAJENDIE, of Smiths Aircraft Instruments, Ltd., has been elected president of the Institute of Navigation.

MR. D. JUBB has been appointed technical manager of Modern Engineering (Bristol), Ltd., Emery Road, Brislington Trading Estate, Bristol, 4.

MUREX WELDING PROCESSES, Ltd., Waltham Cross, Herts, announces that Mr. J. M. Willey, general manager, has been appointed a director.

MR. W. H. BATCHELOR has been appointed commercial director of Perry Barr Metal Company, Ltd., Oscott Works, Great Barr, Birmingham, 22A.

ABWOOD MACHINE TOOLS, Ltd., Princes Road, Dartford, Kent, states that Mr. J. M. Delapena has been appointed home and export sales manager.

MR. D. P. BERTLIN, M.I.C.E., has joined the partnership of Sir Bruce White, Wolfe Barry and Partners, 1, Lygon Place, Grosvenor Gardens, S.W.1.

SCOTTISH AGRICULTURAL INDUSTRIES, Ltd., Edinburgh, states that Dr. Bernard Raistrick, research manager, Mr. J. P. A. Macdonald, chief engineer, and Dr. J. Craik have been appointed to the board of directors.

BRUSH ELECTRICAL ENGINEERING COMPANY, Ltd., announces the following appointments :—Mr. R. D. Taylor, London branch manager ; Mr. G. M. Ingram, Sheffield branch manager ; Mr. D. P. Engert, Ipswich branch manager.

MR. W. D. FARRINGTON, A.C.G.I., has been appointed chief inspecting engineer, Crown Agents for Oversea Governments and Administrations, in succession to Mr. J. W. Norris, A.C.G.I., who is retiring at the end of the month.

MR. SAID OMER EL AWAD has been appointed chief inspecting engineer of the Sudan Government London Agency, in succession to Mr. W. B. G. Swayne, who has resigned. Mr. D. V. Middleton continues as deputy inspecting engineer.

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., Trafford Park, Manchester, announces the appointment of Mr. A. E. Andrew as superintendent of the main production department. He succeeds Mr. A. J. Leslie, who assists the director of manufacture on special problems.

MR. P. L. JONES, director of Swan Hunter and Wigham Richardson, Ltd., has been elected chairman of the National Association of Marine Engine-builders. Mr. J. Ferrier, chairman and managing director of Rankin and Blackmore, Ltd., has been elected vice-chairman.

THE LORD PRESIDENT OF THE COUNCIL has appointed Mr. W. Strath to be a full-time member of the U.K. Atomic Energy Authority. Sir Rowland Smith, chairman of Ford Motor Company, Ltd., and Mr. C. F. Kearton, a director of Courtaulds, Ltd., have been appointed part-time members of the Authority.

THE BRITISH TRANSPORT COMMISSION has announced the following appointments to the staff of British Transport Waterways :—Mr. G. B. Lakin, manager of the Forth and Clyde, Monkland and Union canals ; Brigadier D. H. Bond, mechanical and electrical engineer and stores officer, headquarters staff, Birmingham.

Business Announcements

MR. M. J. REANEY, general manager of Colt Ventilation, Ltd., Surbiton, is making a business trip in the U.S.A.

CATHANODE, Ltd., Vineyard Walk, London, E.C.1, states that its title will be changed to Bowyer, Smyth and Partners, Ltd.

POWELL DUFFRYN TECHNICAL SERVICES, Ltd., states that it has been appointed by the Government of India to draw up detailed plans for the mining of lignite.

SIR ERNEST GOODALE, chairman of British Industries Fair, Ltd., is making a tour in North America to encourage visitors from there to next year's British Industries Fair.

POWER AUXILIARIES, Ltd., has been formed for the production of " Plessiflex " seamless flexible metal hose. The company has been established by the Plessey Company, Ltd., and the D.K. Manufacturing Company of Chicago.

JAMES GORDON AND CO., Ltd., Dalston Gardens, Stanmore, Middlesex, announces an amalgamation with Hall Telephone Accessories, Ltd., Dudden Hill Lane, Neasden, N.W.10.

MR. W. E. EVANS, managing director of the British Tool and Engineering Company, Ltd., Bushbury, Wolverhampton, has left this country for a business tour of South Africa.

HEAD WRIGHTSON PROCESSES, Ltd., has signed an agreement with D. Bonaldi and Co. for the manufacture by the latter company in Italy of Head Wrightson air-cooled heat exchangers.

D. NAPIER AND SON, Ltd., The Vale, Acton, London, W.3, announces an agreement by which the Canadian Marconi Company will manufacture and market throughout Canada the " Napier Spraymat " electrical de-icing system for aircraft.

METROPOLITAN VICKERS ELECTRICAL COMPANY, Ltd., states that Dr. Willis Jackson, F.R.S., director of research and education, received the honorary degree of Doctor of Technical Science at the centenary celebrations of the Federal Institute of Technology, Zurich.

Contracts

F. PERKINS, Ltd., Peterborough, has received an order, worth nearly £1,000,000, for the supply of agricultural tractor engines to Industrija Motora and Industrija Traktora, Yugoslavia. The engines are to be installed in Ferguson tractors, a contract for which has been placed with the Massey-Harris-Ferguson organisation by Industrija Traktora.

THE EAGLE OIL AND SHIPPING COMPANY, Ltd., has ordered a further seven ships, totalling an aggregate of 182,000 tons deadweight, bringing the present building programme to a total of thirteen ships of 316,000 tons deadweight. Of the new order, Cammell Laird and Co. (Shipbuilders and Engineers), Ltd., and the Furness Shipbuilding Company, Ltd., are each to build two 32,000 and one 18,000 tons deadweight tankers, and Smith's Dock Company, Ltd., is to build one ship of 18,000 tons deadweight.

THE BRISTOL AEROPLANE COMPANY, Ltd., has received a contract, valued at 10,000,000 dollars, from Canadian Pacific Airlines, for three " Britannia " 300 LR turbo-prop airliners to be delivered in 1957. Canadian Pacific Airlines has also taken an option on five more " Britannias." Long range is a characteristic of the aircraft, which will be valuable on services radiating from Canada to Tokyo, Hong Kong, Sydney, and Auckland, to Mexico City and Peru, and via the Arctic to Amsterdam.

Miscellanea

LECTURES ON CONCRETE TECHNOLOGY.—We have received from the Cement and Concrete Association, 52, Grosvenor Gardens, London, S.W.1, a lecture list covering the lectures, papers and so forth, on the various aspects of construction in concrete and closely allied subjects, which are to be given throughout the country during the 1955–56 winter session. The list includes details of courses in concrete technology, concrete practice, and so forth.

MECHANICAL HANDLING EXHIBITION.—Last week a new film, " Mechanical Handling on Show," was presented in London by *Mechanical Handling*, which organises the biennial Mechanical Handling Exhibition and Convention. The film surveyed the modern handling equipment and methods displayed at past Mechanical Handling Exhibitions and covered typical examples of all forms of labour-aiding equipment. It provides an introduction to the next exhibition, which will be held at Earls Court from May 9th to May 19th next year. At this exhibition some 250 manufacturers will show products covering mechanical handling and labour-aiding equipment of practically every kind used in industry.

WEAR AND TEES RIVER BOARD.—The fifth annual report of the Wear and Tees River Board, for the year ended March 31, 1955, records continued improvement in the internal drainage of the Board's area. This work included impounds on the River Skerne. A scheme for the improvement of the Billingham Beck, at an estimated cost of £15,000, has been approved by the Board. The first chemical survey of the non-tidal sections of the Wear and Tees was completed during the year covered by the report. It is pointed out that although certain stretches of the two rivers are considered satisfactory, this is an overall assessment, and localised pollution does occur near outfalls or small polluted tributaries.

LLOYD'S WRECK RETURNS.—Lloyd's Register of Shipping has issued its returns of merchant ships totally lost, broken up during the quarter ended March 31st. Steamships and motorships lost consequent upon casualty totalled forty-five ships of 70,623 tons gross and included seven ships of 4176 tons belonging to Great Britain and Northern Ireland and seven ships of 7523 tons belonging to the other Commonwealth countries. The corresponding figures for ships lost not consequent upon casualty are, respectively, 108 ships of 193,250 tons gross, thirty-five ships of 25,966 tons and six ships of 6464 tons.

LONDON TRANSPORT EXECUTIVE.—The Minister of Transport and Civil Aviation, Mr. John Boyd-Carpenter, after consultation with the chairman of the British Transport Commission, has reappointed Sir John Elliot to be chairman and Mr. A. H. Grainger, Mr. L. C. Hawkins and Mr. B. H. Harbour to be full-time members of the London Transport Executive. Mr. Anthony Bull has been appointed a full-time member of the Executive. Mr. John Cliff, deputy chairman and full-time member of the Executive, has expressed his wish to retire at the end of his term of office on September 30, 1955, and the Minister has accepted Mr. Cliff's retirement.

FILM CATALOGUE.—We have received from the Shell Petroleum Company, Ltd., No. 1, Kingsway, London, W.C.2, a catalogue of the films produced by the Shell Film Unit. The films are divided into groups according to subject matter and those listed include films on petroleum which touch upon exploration, production, transportation, refining, products and uses. Other groups relate to aviation, motoring, power and engineering, agriculture and horticulture, and other subjects. The subject matter of each film is briefly outlined and the running time given and the catalogue lists films suitable for universities, technical colleges, museums and schools, and also gives the films available in a number of other languages.

CENTRAL ADVISORY WATER COMMITTEE REVIVED.—Meetings of the central advisory water committee, appointed by the Minister of Housing and Local Government, are being resumed and the first will be held on October 31st. The Minister, Mr. Duncan Sandys, is chairman of the committee, and the vice-chairman is the parliamentary secretary, Mr. William Deedes. The committee was first set up in 1946, under the Water Act, 1945, and has issued a series of reports on river pollution, water softening, gathering grounds and land drainage. Its sittings were suspended in 1952, and its revival has necessitated the appointment of new members. Among the twenty-four members are water engineers, industrialists, scientists and members of River Boards.

ROAD CONSTRUCTION EXHIBITION.—An exhibition of photographs of roads, bridges and garages from all over the world will be held this autumn in the Great Hall of the Institution of Civil Engineers. It will be opened by the Minister of Transport, Mr. John Boyd-Carpenter, M.P., on November 7th, and will then be open to the public from November 8th to 18th from 10 a.m. to 6 p.m. (Sunday excepted). The photographs will show what is being done in other countries to prevent congestion on the roads, new and redesigned roads, involving bridge construction (motorway fly-overs as well as road bridges over water and railways), through roads in cities and the provision of parking garages. Pictures from all countries of Europe as well as the Dominions, the U.S.A., South America and Asia will be shown. The exhibition is being organised by the Institution of Highway Engineers, the Pavings Development Group, and the Joint Committee on Structural Concrete.

NEON AND FLUORESCENT SIGNS.—The Wembley works of Claude-General Neon Lights, Ltd., has recently been extended by the addition of a new frontage accommodating offices and laboratories. The new extension includes possibly the longest continuous strip of fluorescent tubes in Britain, a 300ft stretch of Osram cold cathode tubes. A recent visit to the works afforded us the opportunity to see both " neon " and fluorescent tubes manufactured and incorporated into illuminated signs. A demonstration was given of the mercury trap developed by Claudgen to eliminate darkening of the ends of fluorescent tubes due to condensation of mercury in cold weather. In an address afterwards, the managing director, Mr. S. D. Moyse, drew attention to the Advertisement Regulations made under powers delegated by the Town and Country Planning Act, 1948, to the Minister, pointing out that no outdoor illuminated sign could be erected without sanction of the planning authority or the Minister, and that there were no explicit rules as to what, and where, signs were acceptable. The existing situation was expensive and unjustifiably restrictive.

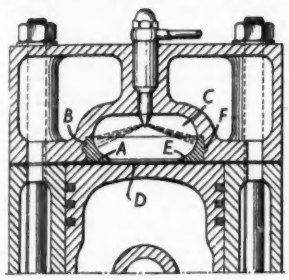
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgement, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. each.

INTERNAL COMBUSTION ENGINES

735,834. September 22, 1953.—CYLINDER HEADS, Société Anonyme Adolphe Saurer, or Aktiengesellschaft Adolph Saurer, Arbon, Switzerland.

According to the invention in a cast cylinder head a constriction or lip defining the opening between the combustion chamber and the cylinder space, which is particularly stressed thermally is provided. It consists of a ring of wrought aluminium alloy having substantially the same thermal conductivity and coefficient of thermal expansion as the material of the



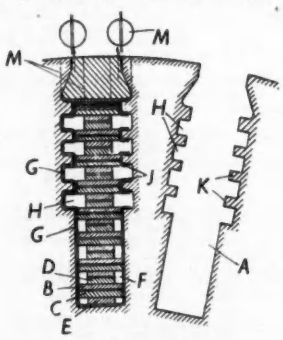
No. 735,834

cylinder head but a considerably greater elongation at rupture. The drawing shows a cylinder head. The insert ring *A* provided in a recess *B* of the cylinder head demarcates the combustion chamber *C* from the cylinder space *D*, the combustion chamber lip *E* forming a constriction between the combustion chamber and the cylinder space. In the drawing the insert ring *A* is connected with the cylinder head during the casting process. The function of the rounded extension part *F* is to secure the insert ring in the cylinder head. Modified designs of insert rings, and the ways of securing them with the cylinder head, are also shown in the specification.—*August* 31, 1955.

ELECTRICAL ENGINEERING

734,107. July 16, 1953.—COOLING A ROTOR WINDING IN THE SLOTS OF A TURBO-ALTERNATOR, Aktiengesellschaft Brown, Boveri et Cie, Baden, Switzerland.

The invention consists in a cooling arrangement for a rotor winding located in the slots of a turbo-alternator, characterised by the feature that the individual conductors have lateral recesses through which the cooling gas flows along the conductors and cools them. In the form illustrated in the drawing conductors are located in rotor slot *A* and insulated from each other. Each conductor consists of a wide conductor *B* and *C* and a narrow conductor *D* and *E*. This results in the formation of recesses *F*. These recesses form axial cooling channels with a relatively large cooling surface. The sectional shape is such that the outer edge of the section, except for the outlet openings for the gas, adjoins lateral slot insulations *G* and *J*, respectively, over its entire length. By this means each conductor is fixed



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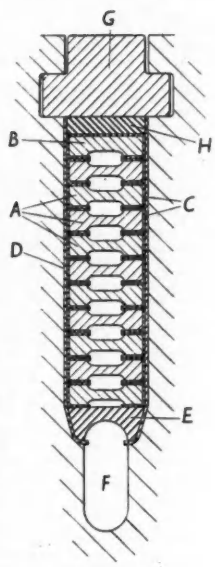
laterally along its entire length, so that any displacement and deformation is avoided. In order to increase the cross-section of the channels formed by the conductors corresponding longitudinal channels *H* can be recessed out of the teeth, these channels coinciding with those formed by the conductors. Where these enlarged channels occur it is possible to make the slot insulation discontinuous by providing individual insulating channel strips *J* which are located on projections *K* between the recesses or channels *H* in the rotor teeth. The limbs of these insulating strips are only made so long that there is an adequate leakage path for maintaining the voltage. A maximum amount of the tooth surface in the channels can thus be in direct contact with the cooling gas. As the gas passes through the channels it becomes heated and part of this heat can be transmitted directly to the rotor teeth. These teeth become heated and the temperature difference between the winding and the rotor teeth is thus reduced to a minimum. The projecting parts of the conductor profiles are cut away at various points along the axial length of the conductor, so that radial channels are formed which connect the individual longitudinal channels with each other. Radial holes *M* are provided at corresponding points in the rotor teeth and slot wedge through which the gas can escape due to the centrifugal effect. A double "T"-form of conductor composed of four individual flat copper elements is also shown in the specification.—*July* 27, 1955.

735,142. May 21, 1953.—DYNAMO ELECTRIC MACHINES, C. A. Parsons and Co., Ltd., Heaton Works, Newcastle upon Tyne, 6. (*Inventor: William Douglass Horsley.*)

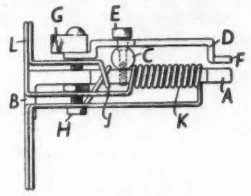
This invention relates to the construction of dynamo-electric machines and to the ventilation of the rotors of large high-speed alternating current generators. In carrying the invention into effect, as shown in the drawing, eleven conductors are provided in each slot of a rotor. All these conductors *A*, with the exception of the outermost conductor *B*, which is of channel section, are of dumb-bell section. Adjacent conductors are separated from each other by a pair of channel section interturn insulation strips *C* separated from the sides of the rotor slots by further insulating strips or liners *D*. At the base of each slot a pad *E* of insulating material is provided and beneath this is a sub-slot *F* for the passage of cooling gas to the centre of the rotor. Each winding slot is closed by a retaining wedge *G* of suitable material, steel, bronze or aluminium, with a pad *H* of insulating material separating it from the outer conductor. Radial ventilation holes are provided at intervals along the length of the conductors *A* in each slot. The radial holes at the centre and at each end of the rotor enable gas to enter the longitudinal ducts between the coil turns from whence it flows to further radial holes, through which it is discharged into the gap between the rotor surface and the stator bore, thus completing the circuits through the embedded portion of the windings. The specification shows the application of this system of cooling to large alternator rotors.—*August* 17, 1955.



No. 735,142

737,320. December 1, 1952.—ELECTRICALLY OPERATED TIME DELAY OVERLOAD RESPONSIVE DEVICES, Foster Transformers, Ltd., South Wimbledon, London, S.W.19, and Robert Ironside Bagnall, Bembridge, 99, Bourne Way, Hayes, Kent.

The invention relates to improvements in electrically operated time delay overload responsive devices, particularly to an overload trip device for circuit breakers, designed to operate with an inverse time delay action and to operate substantially instantaneously for an overload in excess of a certain value. The device, as shown in the drawing, comprises a magnetisable core *A* of soft iron having an angle end portion *B* serving as a support for the device. The core *A* is covered with insulating material such as wrappings of glass fibre tape. A pivot mounting *C* is provided for an armature *D* to rock towards either end of the core. The pivot mounting may consist of a piece of circular rod material or one or more spheres, and the armature is pressed resiliently against the mounting by its own mass or by a spring, and is located in relation to it by means of suitable shouldered screws *E*. The armature is cranked towards one end *F* and the other end is also cranked and is provided with a counterweight *G* or may be subjected to a spring to produce contact with an adjustable, non-magnetic stop screw *H* in the core *A*. The hold-on coil *J* may consist of a single turn of copper wire or strip as shown or a few turns of wire or strip and is disposed between the stop screw *H* and the pivot mounting *C* of the armature. The pull-off coil *K*, consisting of, say, ten or twelve turns (where the hold-on coil *J* consists of a single turn), is wound on the core towards the cranked end *F* of the armature. The ends of coils *J* and *K* may be suitably



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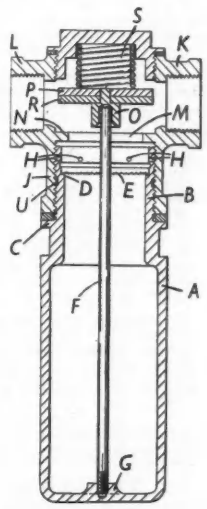
bent and looped at the ends as indicated at *L*, or secured to terminal blocks or the like to enable them to be connected in parallel one with the other and in series in the load circuit. In the form shown the armature *D* remains in the biased position against the screw *H* for normal loads. For moderate overloads the distribution of current in the two coils changes due to the greater heating of the hold-on coil *J*, and after a time delay inverse in sense to the amount of overload the armature is actuated by the pull-off coil *K* to perform the required function—for example, to trip a circuit breaker. For a greater overload in excess of a given value, the armature *D* reverses in position immediately due to the greater proportionate pull effective on the armature—that is, without heating of the coils to an appreciable extent. —*September* 21, 1955.

FEED [WATER] DEVICES

736,014. June 24, 1952.—WATER SOFTENING OR SCALE REDUCING, Main Water Heaters, Ltd., 48, Grosvenor Gardens, London, S.W.1. (*Inventor: James Emerson.*)

The invention relates to water softening or scale reducing devices in which a container for a charge of suitable chemical is detachably connected to a limb of a T-piece, the other two limbs of which are arranged for assemblage in a pipeline as will be seen from the drawing. The softener comprises a substantially cylindrical containers *A* for holding a suitable scale inhibiter such as meta-phosphate. It is provided with a reduced neck *B* which is externally threaded, and there is formed at the base of the threaded portion a shoulder *C*. An internal shoulder is provided at *D* on which rests a metal gauze *E*; the gauze is retained in position by frictional engagement with a spindle *F* which passes up through a hole in it, the lower end of the spindle being fixed to a boss *G* at the bottom of the container. The threaded neck is provided with a number of small holes *H*, above the gauze *E*. The neck is engaged by the threaded branch *J* of a T-connection, the other two limbs *K* and *L* of the connection being threaded to engage a water supply and delivery pipe respectively. The cross passage communicates through an aperture *M* with the interior of the container which is encircled by a flat valve seat *N*. Mounted loosely at the upper end of the spindle *F* is a hollow boss *O* which has on the upper side a threaded stem which screws in a plate valve *P*. The underside of the plate valve has a resilient washer *R* gripped between the hub *O* and the plate. Pressing on the upper face of the plate valve is a spring *S*. When it is required to replenish the container with scale inhibiter it is unscrewed from the part *J* and in so doing the valve descends and engages the seat *N* before the reduced neck *B* leaves the part *J*. During the unscrewing of the neck the small holes *H* will eventually pass the end of the part *J* and by this time the valve should have reached its seat and sealed the opening *M* from the supply of water. Should, however, the valve not have sealed properly, water will leak through the small holes *H* and along the threads and out past the shoulder *C* thus giving an indication that the valve is not properly sealed.—*August* 31, 1955.



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Launches and Trial Trips

BARON GLENCONNER, cargo ship; built by the Caledon Shipbuilding and Engineering Company, Ltd., for H. Hogarth and Sons, Ltd.; length overall 461ft 3in, length between perpendiculars 430ft, breadth moulded 58ft, depth moulded to shelter deck 37ft 6in, draught loaded 25ft 3in, deadweight 9500 tons, gross tonnage 5468 tons, trial speed 12½ knots; five cargo holds, ten 5-ton derricks, steam deck machinery; two 100kW steam-driven generators; machinery built by John G. Kincaid and Co., Ltd., a single-screw, triple-expansion reciprocating steam engine of 3350 i.h.p., Bauer-Wach turbine, superheated steam supplied at 220 lb per square inch by three oil-fired boilers. Trial, September 15th.

SANDRINGHAM QUEEN, coaster; built by the Goole Shipbuilding and Repairing Company, Ltd., for Queenship Navigation, Ltd.; length between perpendiculars 220ft, breadth 35ft 6in, depth 15ft 6in, deadweight 1710 tons, trial speed 12 knots; British Polar "M47M" diesel engine, 1120 b.h.p. at 250 r.p.m.—Trial, September 27th.

KAWERAU, cargo ship; built by Alexander Stephen and Sons, Ltd., for the Union Steam Ship Company of New Zealand, Ltd.; length 325ft, breadth 50ft, depth 26ft, deadweight 5300 tons; three holds, twelve derricks, electric deck machinery; Stephen-Sulzer single-acting diesel engine, six cylinders, 600mm diameter by 1040mm stroke, 2410 b.h.p. at 128 r.p.m., overload power of 3000 b.h.p. at 150 r.p.m. Trial, September 29th.

CITY OF WINNIPEG, cargo liner; built by the Caledon Shipbuilding and Engineering Company, Ltd., for Ellerman Lines, Ltd.; length overall 505ft, breadth moulded 65ft 6in, depth moulded to shelter deck 42ft, deadweight 10,200 tons, sea speed 15 knots; five cargo holds, one 70-ton, two 12-ton, six 10-ton, four 7-ton and four 5-ton derricks, electric deck machinery; one 320kW and two 240kW diesel-driven generators, two oil-fired boilers, one Doxford opposed piston oil engine, six cylinders, 8000 b.h.p. at 105 r.p.m.—Launch, September 29th.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

BRITISH INSTITUTION OF RADIO ENGINEERS

Thurs., Nov. 3rd.—N.W. SECTION: Reynolds Hall, College of Technology, Sackville Street, Manchester, "Ground-Controlled Approach and the Instrument Landing System," R. H. James and N. Mackinnon, 6.30 p.m.

Wed., Nov. 9th.—N.E. SECTION: Neville Hall, Westgate Road, Newcastle upon Tyne, "Turret Tunes for Multi-Channel Television Reception," R. Holland, 6 p.m.—MERSEYSIDE SECTION: Chamber of Commerce, 1, Old Hall Street, Liverpool, 3, "The Dekatron Tube in a Digital Transmission System," G. Shand, 7 p.m.——W. MIDLANDS SECTION: Technical College, Wulfruna Street, Wolverhampton, "Closed Circuit Industrial Television," H. A. McGhee, 7.15 p.m.

Thurs., Nov. 10th.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Some Applications of Electronics to Marine Echo-Sounding," F. Baillie, 7 p.m.

CEMENT AND CONCRETE ASSOCIATION

Mon., Oct. 31st.—CAMBRIDGE AND DISTRICT ASSOCIATION OF BUILDERS' FOREMEN AND CLERKS OF WORKS: Technical College and School of Art, Collier Road, Cambridge, "Cement Manufacture and Some Recent Developments in Special Cements," E. S. Snellard, 7.30 p.m.

CHEMICAL SOCIETY

Mon., Oct. 31st.—NEWCASTLE AND DURHAM BRANCH: Science Laboratories, South Road, Durham, "Recent Researches on the Metal Alkoxides," W. Wardlaw, 5.15 p.m.

ELECTRIC RAILWAY SOCIETY

Thurs., Nov. 3rd.—Fred Tallant Hall, 153, Drummond Street, London, N.W.1, "The Maintenance of Electric Railway Rolling Stock," J. P. J. Keeling, 7.15 p.m.

ILLUMINATING ENGINEERING SOCIETY

Thurs., Nov. 3rd.—GLASGOW CENTRE: Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, C.2, "Maintenance of Lighting Installations," J. W. Strange and W. Robinson, 6.30 p.m.

Mon., Nov. 7th.—LEEDS CENTRE: Yorkshire Electricity Board, Ferensway, Hull, "Some Developments in Fluorescent Lighting," H. H. Ballin, 7 p.m.

Tues., Nov. 8th.—LONDON CENTRE: Lighting Service Bureau, 2, Savoy Hill, W.C.2, "Efficiency of Fluorescent Lamps," F. Jackson, R. Molloy and K. Scott, 6 p.m.

Wed., Nov. 9th.—NEWCASTLE CENTRE: Grey Hall, Department of Electrical Engineering, King's College, College Road, Newcastle upon Tyne, 1, "The Architect's Approach to Artificial Lighting Design," G. Grenfell Baines, 6.15 p.m.

INCORPORATED PLANT ENGINEERS

To-day, Oct. 28th.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Oil Firing," K. J. Luntley, 7.30 p.m.

Mon., Oct. 31st.—W. AND E. YORKS BRANCH: The University, Leeds, "Raising of H.M. Submarine 'Truculent,'" L. Hackman, 7.30 p.m.

Tues., Nov. 1st.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Adelphi, Strand, W.C.2, "Corrosion and Fouling in Industry," E. J. Bradbury, 7 p.m.——EDINBURGH BRANCH: 25, Charlotte Square, Edinburgh, "Factory Heat Analysis," G. E. H. Lewis, 7 p.m.

Wed., Nov. 2nd.—LEICESTER BRANCH: College of Art and Technology, The Newarkes, Leicester, "Combustion Systems for Aero-Gas Turbines," S. L. Bragg, 6.30 p.m.——SOUTHERN BRANCH: Polygon Hotel, Southampton, "Industrial Fires and their Prevention," E. T. Hayward, 7.30 p.m.

Thurs., Nov. 3rd.—PETERBOROUGH BRANCH: Campbell Hotel, Bridge Street, Peterborough, "Engineering Economics," T. S. Welch, 7.30 p.m.

Tues., Nov. 8th.—MANCHESTER BRANCH: Engineers' Club, Albert Square, Manchester, "Power Without Smoke," and "Distinguished Company," films, 7.15 p.m.

Wed., Nov. 9th.—E. MIDLANDS BRANCH: County Hotel, Theatre Square, Nottingham, "Atomic Energy and the Future," J. A. Dixon, 7 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Nov. 8th.—SLOUGH SECTION: Lecture Theatre, High Duty Alloys, Ltd., Slough, "Production of Moulds and Cores by the CO_2 Process," A. Talbot, 7.30 p.m.

INSTITUTE OF FUEL

Fri., Nov. 4th.—S. WALES SECTION: Central Library, Alexandra Road, Swansea, "Electrical Hazards in Inflammable Atmospheres," G. D. Curtis, 6 p.m.

Wed., Nov. 9th.—LONDON SECTION: Institution of Civil Engineers, Great George Street, London, S.W.1, "Chimneys and the Dispersal of Smoke," J. E. Hawkins and G. Nonhebel, 5.30 p.m.

INSTITUTE OF INDUSTRIAL SUPERVISORS

Thurs., Nov. 3rd.—LONDON CENTRAL SECTION: The Polytechnic, Regent Street, London, W.1, "Managerial Authority," D. H. Bramley, 7.30 p.m.

INSTITUTE OF METALS

Tues., Nov. 8th.—Royal Institution, Albemarle Street, London, W.1. Symposium on "The Mechanism of Phase Transformations in Metals," 10 a.m. to 12.30 p.m. and 2.15 p.m. to 5 p.m. "The Shape of Grains in Single-Phase and Two-Phase Alloys," Cyril S. Smith, 8.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Nov. 9th.—26, Portland Place, London, W.1, "Preflame Reactions in a Diesel Engine," F. H. Garner, G. H. Grigg, F. Morton and W. D. Reid, 5.30 p.m.

INSTITUTE OF REFRIGERATION

Thurs., Nov. 3rd.—Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, Presidential Address, Lieut.-Colonel Lord Dudley Gordon, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., Nov. 1st.—EASTERN CENTRE: F. Perkins, Ltd., Peterborough, "Two-Way Radio as an Aid to the Control of Large Fleets of Goods and Passenger Vehicles," E. N. Farrar, 6.30 p.m.

Wed., Nov. 2nd.—WESTERN CENTRE: Royal Hotel, Bristol, "A Talk on Girling Products and the Servicing of Same," T. J. Phipps, 7.30 p.m.

Mon., Nov. 7th.—SCOTTISH CENTRE: North British Hotel, Edinburgh, "A Talk on Fibreglass for Road Transport," C. M Johnson, 7.30 p.m.

Tues., Nov. 8th.—MIDLAND CENTRE: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Indivisible Loads," S. Bowskill, 7.30 p.m.

INSTITUTE OF WELDING

Wed. to Fri., Nov. 2nd to 4th.—AUTUMN MEETING: Wednesday: Park Lane Hotel, Piccadilly, London, W.1, Annual Dinner. Thursday: Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Presidential Address, R. E. G. Weddell; "Some Electrical Aspects of Inert-Gas Shielded-Arc Welding Processes," L. H. Orton and J. C. Needham; "The Economics of the Joining of Aluminium and its Alloys by the Inert-Gas Shielded Welding Processes," J. G. Young, 10 a.m.; "Dilution and Uniformity in Aluminium Alloy Weld Beads," P. T. Houldcroft; "Development of a Simple Weld-Cracking Test for Aluminium Alloys," P. T. Houldcroft, 2.30 p.m.; Friday: "The Welding of Nickel and High-Nickel Alloys by the Inert-Gas Shielded-Arc Welding Processes," J. Hinde and D. R. Thorneycroft; "Inert-Gas-Shielded Self-Adjusting Metal-Arc Welding of Copper and Copper Alloys," D. C. Moore and E. A. Taylor; "A Mathematical Examination of the Effect of Bounding Planes on the Temperature Distribution Due to Welding," Doris K. Roberts and A. A. Wells; "Energy Distribution in Argon-Shielded Welding Arcs," J. F. Lancaster, 10 a.m.; "The Testing and Inspection of Welds in Aluminium and Aluminium Alloy Plate," P. Bradley; "Some Factors Affecting Design of Aluminium Alloy Fabrications Welded by the Inert-Gas-Shielded Metal-Arc Process," A. L. Hale; "Inert-Gas Arc Welding: Forward Trends in the Gas Turbine Industry," F. C. G. Sandiford, R. T. Weatherstone, O. J. Brown, K. H. McDowell and L. Camidge, 2.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Nov. 2nd.—LONDON GRADUATES' AND STUDENTS' SECTION: Visit to the Fawley Refinery of Esso Petroleum, Ltd., meet at Charing Cross Underground Station, 9 a.m.

Wed., Nov. 9th.—MIDLANDS BRANCH: Midlands Institute, Birmingham, "Handling of Alcohols and Other Solvents," F. H. Walmsley, 6.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Nov. 1st.—ORDINARY MEETING: Great George Street, Westminster, London, S.W.1, Presidential Address, W. K. Wallace, 5.30 p.m.

Tues., Nov. 8th.—PUBLIC HEALTH MEETING: Great George Street, Westminster, London, S.W.1, "The Development of Sewage Treatment in the City of Coventry," Granville Berry and C. R. Deeley, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., Oct. 31st.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, "The Technique of Ionospheric Investigation using Ground Back-Scatter," E. D. R. Shearman; "A Study of Ionospheric Propagation by Means of Ground Back-Scatter," E. D. R. Shearman; "An Experiment to Test the Reciprocal Radio Transmission Conditions Over an Ionospheric Path of 740km," R. W. Meadows; "An Experimental Test of Reciprocal Transmission Over Two Long-Distance High-Frequency Radio Circuits," F. J. M. Laver and H. Stanesby, 2.30 p.m.; "V.H.F. Propagation by Ionospheric Scattering and its Application to Long-Distance Communication," W. J. Bray, J. A. Saxton, R. W. White and G. W. Luscombe, 5.30 p.m.

Tues., Nov. 1st.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, Discussion on "Fault Recording Instrumentation on a Power Supply System," opened by W. Casson and Laszlo Csuros, 5.30 p.m.——S.E. SCOTLAND SUB-CENTRE: Heriot-Watt College, Chambers Street, Edinburgh, "Induction Generators," H. E. C. Clapham, 7 p.m.

Wed., Nov. 2nd.—LONDON GRADUATES' AND STUDENTS' SECTION: Savoy Place, London, W.C.2, "Communication of Information—Human, Animal and Machine," E. Colin Cherry, 6.30 p.m.

Thurs., Nov. 3rd.—ORDINARY MEETING: Savoy Place, London, W.C.2, "The New High-Frequency Transmitting Station at Rugby," C. F. Booth and B. N. Maclarty, 5.30 p.m.

Mon., Nov. 7th.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Lagrange's Principle as the Basis of a Unified Treatment of the Action of Electrical Indicating Instruments," opened by D. Rutenburg, 6 p.m.——S. MIDLAND CENTRE: James Watt Memorial Institute, Birmingham, "The Electrification of the Manchester-Sheffield-Wath Lines," J. A. Broughall, 6 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Tues., Nov. 8th.—Bull Hotel, Rochester, Kent, "The Design and Application of Vee Belt Drives," J. Mitchell, 7 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Tues., Nov. 1st.—Room A5, Technical College, Coventry, "Quality Castings in Light Alloys," P. A. Broadbent, 7.30 p.m.

Wed., Nov. 2nd.—Exchange and Engineering Centre, Birmingham, "Measurement for Production," S. F. Ellerby, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Nov. 1st.—39, Elmbank Crescent, Glasgow, C.2, "Aluminium Tanker," E. C. B. Corlett, 7.30 p.m.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS

Wed., Nov. 2nd.—E. MIDLANDS BRANCH: College of Arts and Crafts, Waverley Street, Nottingham, "Medium Pressure Hot Water Systems," T. H. F. Holman, 6.45 p.m.

Thurs., Nov. 3rd.—BIRMINGHAM AND DISTRICT BRANCH: Exchange and Engineering Centre, Stephenson Place, Birmingham, Film Evening, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Oct. 28th.—GENERAL MEETING, APPLIED MECHANICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "The Value of the Notch Tensile Test," J. F. Baker and C. F. Tipper, 5.30 p.m.

Wed., Nov. 2nd.—E. MIDLANDS BRANCH: Room C4, Engineering Department, The University, Nottingham, "Co-operation in Engineering Research Between Educational Institutions and Industry," E. Giffen, V. C. Davies and J. H. R. Nixon, 7.30 p.m.

Thurs., Nov. 3rd.—EASTERN BRANCH: Good Companions Hotel, Slough, Chairman's Address, "Aero-Engines—Past, Present and Future," A. D. Baxter, 7.30 p.m.——N.W. BRANCH: Engineers' Club, Albert Square, Manchester, "Rapid Starting Technique: Some Significant Tests at Poole Power Station," J. S. Hall and A. D. Brittin, 6.45 p.m.

Fri., Nov. 4th.—GENERAL MEETING, HYDRAULICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Experiments on a Small Pump Suction Well, with Particular Reference to Vortex Formations," E. Markland and J. A. Pope; "An Experimental Study of Air-Entraining Vortices in Pump Sumps," D. F. Denny, 5.30 p.m.

Tues., Nov. 8th.—AUTOMOBILE DIVISION: 1, Birdcage Walk, Westminster, London, S.W.1, "Disk Brakes," F. G. Parnell and F. J. Bradbury, 5.30 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Tues., Nov. 8th.—ORDINARY MEETING: Institution of Electrical Engineers, Savoy Place, London, W.C.2, "Economic Principles of Telecom's Plant Provision," N. V. Knight, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Tues., Nov. 1st.—TEES-SIDE SECTION: Cleveland Scientific and Technical Institution, Middlesbrough, "The Practical Application of Production Engineering Research," D. F. Galloway 7 p.m.

Wed., Nov. 2nd.—WOLVERHAMPTON SECTION: Technical College, Stafford, "Increased Automation of Existing Production Lines," J. B. Jay, 7.15 p.m.——PETERBOROUGH SECTION: Campbell Hotel, Bridge Street, Peterborough, "The Shell Moulding Process," D. N. Buttrey, 7.30 p.m.——S. ESSEX SECTION: Ilford Club, 21a, Balfour Road, Ilford, "Powder Metallurgy," G. R. Bell, 7.30 p.m.

Thurs., Nov. 3rd.—READING SECTION: The Canteen, Transport Equipment (Thornycroft), Ltd., Basingstoke, "Glass Fibre and its Use in Reinforced Plastics," A. R. Hennings, 7.30 p.m.——GLASGOW SECTION: Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank Crescent, Glasgow, C.2, Open Discussion, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

To-day, Oct. 28th.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Birmingham, Chairman's Address, W. D. Christie, 6 p.m.

Tues., Nov. 1st.—MIDLAND COUNTIES BRANCH: Midland Institute, Birmingham, "Design of a Building," E. Shepley, 6 p.m.——NORTHERN COUNTIES BRANCH: Cleveland Scientific and Technical Institution, Middlesbrough, "Castellated Construction," H. Saunders, 6.30 p.m.——WALES AND MONMOUTHSHIRE BRANCH: S. Wales Institute of Engineers, Cardiff, "Recent Trends in the Design of Industrial Buildings," A. V. Hooker, 6.30 p.m.

Wed., Nov. 2nd.—N. COUNTIES BRANCH: Neville Hall, Newcastle upon Tyne, "Castellated Construction," H. Saunders, 6.30 p.m.

Thurs., Nov. 3rd.—MIDLAND COUNTIES BRANCH: Becket Sale Rooms, Derby, "Derby Station—Reconstruction of Platform Roofs," W. C. Clenshaw. 7 p.m.

Sat., Nov. 5th.—S.W. COUNTIES BRANCH: Duke of Cornwall Hotel, Plymouth, Chairman's Address, R. Hazzledine, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Oct. 28th.—INFORMAL MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Some Problems from a Structural Consultant's Case Book," L. Turner, 7 p.m.

Wed., Nov. 2nd.—MIDLAND SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "The Design, Control and Operation of Metallurgical Furnaces for the Non-Ferrous Metals Industry," R. M. Jones, 7 p.m.

Fri., Nov. 4th.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Film Evening, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

Fri., Nov. 4th.—Engineers' Club, Albert Square, Manchester, "The Management of Men," W. D. L. Greer, 6.45 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Oct. 28th.—Bolbec Hall, Newcastle upon Tyne, 1, "Ferrous Materials in Marine Engineering," S. F. Dorey, 6.15 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Nov. 1st.—N.W. BRANCH: College of Technology, Sackville Street, Manchester, "New Northam Bridge, Southampton," J. Cuerel, 6.45 p.m.

Wed., Nov. 2nd.—N.W. BRANCH: Liverpool Engineering Society, The Temple, 24, Dale Street, Liverpool, "New Northam Bridge, Southampton," J. Cuerel, 6.30 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Nov. 8th.—SECTION LECTURE: The Library, 4, Hamilton Place, London, W.1, "High Aspect Ratio Wings," M. Hurel, 7 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., Nov. 1st.—B.I.S.R.A. Laboratories, Hayle Street, Sheffield, 3, "Strain-Ageing in Deep Drawing Mild Steels," B. B. Hundy, 7 p.m.

Tues., Nov. 8th.—B.I.S.R.A. Laboratories, Hoyle Street, Sheffield, 3, "Electric Arc Furnaces—Walls and Roof," A. H. B. Cross, 7 p.m.

SOCIETY OF ENGINEERS

Mon., Nov. 7th.—Geological Society, Burlington House, Piccadilly, London, W.1, "Investigation into the Design of the Superstructure of a Power Station," C. W. E. Dudley, 5.30 p.m